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CONTENTS

I. On the Mathematical Expectation of the Moments of Fr[illegible] By Professor A. TCHOUPROW of Petrograd.—Part II. [illegible] Application of [illegible] Law to Practice. By STUDENT.—III. The Criterion [illegible] Fit of [illegible] By GEORGE H. THOMSON, D.Sc. (One Diagram in text.)—IV. On [illegible] Related Range Frequency Distributions when [illegible] the Ratio of [illegible] of the Range. By ELEANOR FAIRMAN and KARL PEARSON, F.R.S.—V. Editorial.—VI. Quadrangular Confluence for Sheppard's [illegible] VII. On generalised Tchebycheff Theorems in the Mathematical [illegible] F.R.S.—VIII. CHARLES B. GOMPERTZ, 1870—1919. Obituary [illegible] IX. On the Nest and Egg of the Common Tern (*S. fluviatilis*) [illegible] II—VI and One Diagram in text.)—[illegible] On the Degree of [illegible] Correlation Coefficients. By G[illegible] D.Sc. [illegible]

MISCELLANEA: (i) [illegible] (ii) Variation and Distribution of [illegible] in Sc[illegible] By ETHEL M. ELDERTON.—(iv) The [illegible] in the Soil in [illegible] Tubercle Bacillus and the Adoption of [illegible] Treatment. [illegible] One Diagram in text.)

Cambridge University Press, Fetter Lane, [illegible]

# MOTOR POINTS IN RELATION TO THE SURFACE OF THE BODY

By R. W. REID, M.D., F.R.C.S.

*Professor of Anatomy, University of Aberdeen.*

Following upon a visit with the late Professor Paterson, University of Liverpool, to the Orthopoedic Hospital at Shepherd's Bush, London, and upon subsequent visits to the Orthopoedic Department of the First Scottish General Hospital in Aberdeen, I was much impressed with the value of electrical methods employed in the diagnosis and treatment of the results of cases of peripheral nerve lesions, and as an anatomist I thought I might do something to help in the matter.

Accordingly I decided to make a special dissection of a subject in order to show the relation of the points of entrance of the nerves into muscles with regard to the surface of the body and then to make the results of this investigation available in a graphic form for those practising these methods.

With this end in view I considered that the best plan was first to make a cast of a subject in its entire state and thereafter to have the subject dissected with the sole purpose of showing the various points where the several nerves entered the muscles and then to relate these points to the surface of the cast. Accordingly a cast was made in the Anatomy Department of this University of one half of a muscular male subject. The body was subsequently dissected in order to expose its muscles with the nerves entering them and then by comparison and measurement the points of entry of nerves into the several muscles were marked on the surface of the cast.

As this cast had unfortunately undergone a certain amount of distortion owing to the flattening of the soft parts by the weight of plaster, I deemed it advisable to make another cast of a living muscular male and to transfer by proportional measurement the marks indicated on the first cast to the surface of the second one. Photographs of the second cast were then made from different points of view as shown in the accompanying Plates XXVI–XXXIV.

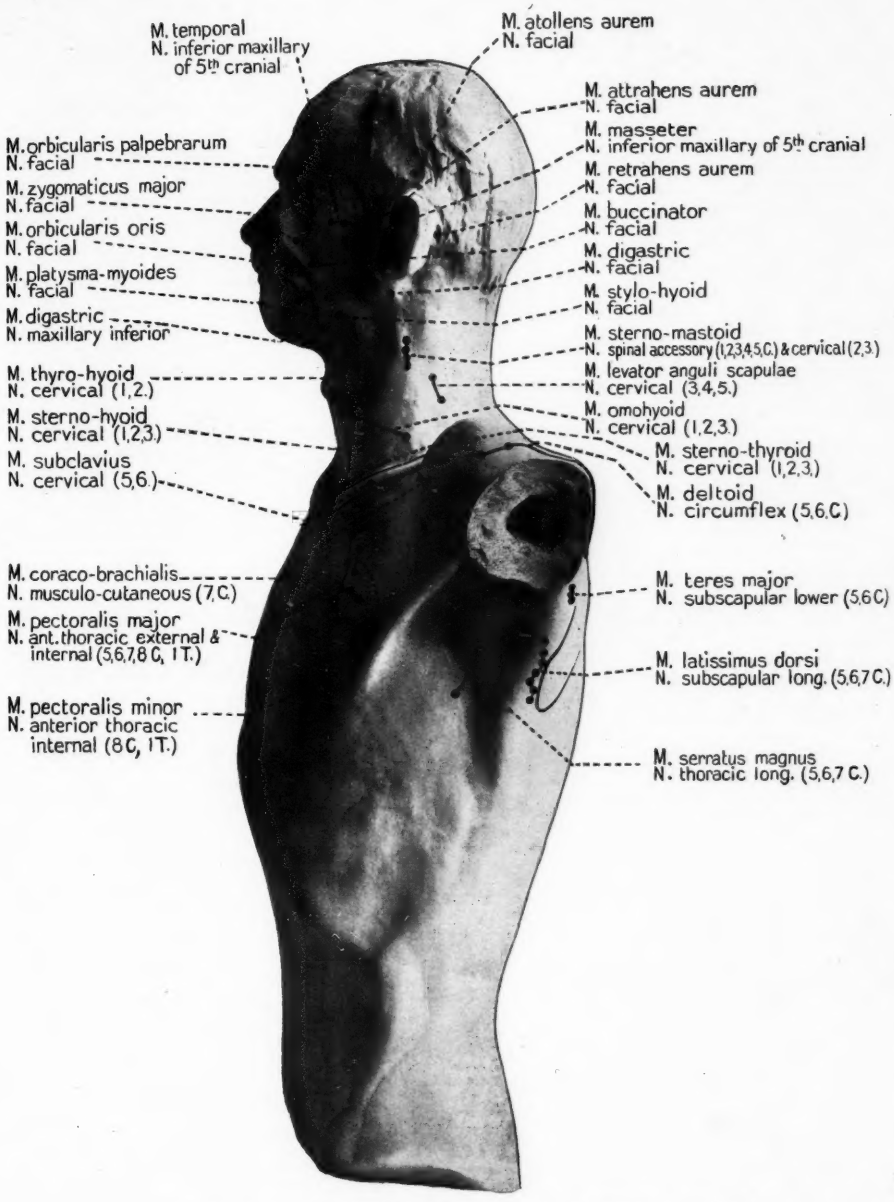
Subjoined is a table showing the number of the principal nerve branches entering each muscle together with the approximate places of entry into each muscle. The segments of the spinal cord from which the nerve supplies are derived are also indicated in the table and this information has been obtained from Gray's *Anatomy, Descriptive and Applied*, 19th edition.

It may be mentioned that the markings refer to the special dissection of a single cadaver but by comparison with cadavera which were being dissected in the course of ordinary practical anatomy work, I find that they are not subject to more variation than might be considered normal.

| Muscle | Nerve supply | Origin from segments of spinal cord | Number of points of entry into muscle | Place of entry into muscle | Relation to surface of body |
|---|---|---|---|---|---|
| Attrahens aurem | Facial | — | 1 | Superficial surface, middle third | Plates 26, 27 |
| Attollens aurem | Facial | — | 1 | Superficial surface, middle third | Plates 26, 27 |
| Retrahens aurem | Facial | — | 1 | Superficial surface, middle third | Plates 26, 29 |
| Orbicularis palpebrarum | Facial | — | 4 | Deep surface, middle third | Plates 26, 27 |
| Zygomaticus major | Facial | — | 1 | Deep surface, upper third | Plates 26, 27 |
| Buccinator | Facial | — | 3 | Superficial surface, middle third | Plates 26, 27 |
| Orbicularis oris | Facial | — | 3 | Superficial surface, near corner of mouth | Plates 26, 27 |
| Masseter | Inferior maxillary | — | 1 | Deep surface, just below zygoma | Plates 26, 27 |
| Temporal | Inferior maxillary | — | 3 | Deep surface, just above zygoma | Plates 26, 27 |
| Platysma myoides | Facial | — | 5 | Deep surface, upper third | Plates 26, 27 |
| Sterno-mastoid | Spinal accessory | 1, 2, 3, 4, 5, C. | 4 | Superficial surface, lower third<br>Deep surface, middle third | Plates 26, 27 |
| | Cervical | 2, 3, C. | | | |
| Digastric | Inferior maxillary | — | 1 | Deep surface, middle third | Plates 26, 27 |
| | Facial | — | 1 | Superficial surface, upper fifth | |
| Stylo-hyoid | Facial | — | 1 | Superficial surface, middle third | Plates 26, 27 |
| Sterno-hyoid | Cervical | 1, 2, 3, C. | 2 | Superficial surface, middle third | Plates 26, 27 |
| Sterno-thyroid | Cervical | 1, 2, 3, C. | 1 | Deep surface, lower third | Plates 26, 27 |
| Thyro-hyoid | Cervical | 1, 2, C. | 1 | Superficial surface, upper third | Plates 26, 27 |
| Omohyoid | Cervical | 1, 2, 3, C. | 2 | Deep surface, anterior belly, middle third<br>Deep surface, posterior belly, upper third | Plates 26, 27 |
| Trapezius | Spinal accessory | 1, 2, 3, 4, 5, C. | 8 | Deep surface, middle third | Plate 29 |
| | Cervical | 3, 4, C. | | | |
| Latissimus dorsi | Long subscapular | 5, 6, 7, C. | 7 | Deep surface, upper third | Plates 27, 29 |
| Rhomboideus major | Cervical | 5, C. | 2 | Deep surface, middle third | Plate 29 |
| Rhomboideus minor | Cervical | 5, C. | 1 | Deep surface, middle third | Plate 29 |
| Pectoralis major | External and internal anterior thoracics | 5, 6, 7, 8, C. 1, T. | 9 | Deep surface, middle third | Plates 26, 27 |
| Pectoralis minor | Internal anterior thoracic | 8, C. 1, T. | 2 | Deep surface, middle third | Plates 26, 27 |
| Subclavius | Cervical | 5, 6, C. | 1 | Deep surface, middle third | Plates 26, 27 |
| Serratus magnus | Long thoracic | 5, 6, 7, C. | 5 | Superficial surface, anterior third | Plates 26, 27 |
| Deltoid | Circumflex | 5, 6, C. | 8 | Deep surface, middle third | Plates 26, 27 |
| Supraspinatus | Suprascapular | 5, 6, C. | 2 | Deep surface, middle third | Plate 29 |
| Infraspinatus | Suprascapular | 5, 6, C. | 3 | Deep surface, middle third | Plate 29 |
| Teres minor | Circumflex | 5, C. | 3 | Deep surface, outer third | Plate 29 |
| Teres major | Lower subscapular | 5, 6, C. | 3 | Deep surface, middle third | Plates 26, 29 |
| Coraco-brachialis | Musculocutaneous | 7, C. | 2 | Deep surface, upper third | Plates 26, 27 |
| Biceps flexor cubiti | Musculocutaneous | 5, 6, C. | 5 | Deep surface, middle third | Plate 27 |
| Brachialis anticus | Musculocutaneous | 5, 6, C. | 4 | Superficial surface, middle third | Plate 27 |
| Triceps extensor | Musculospiral | 7, 8, C. | 9 | Deep surface, upper third | Plate 29 |
| Pronator radii teres | Median | 6, C. | 2 | Deep surface, upper third | Plate 27 |
| Flexor carpi radialis | Median | 6, C. | 1 | Deep surface, upper third | Plates 27, 28 |

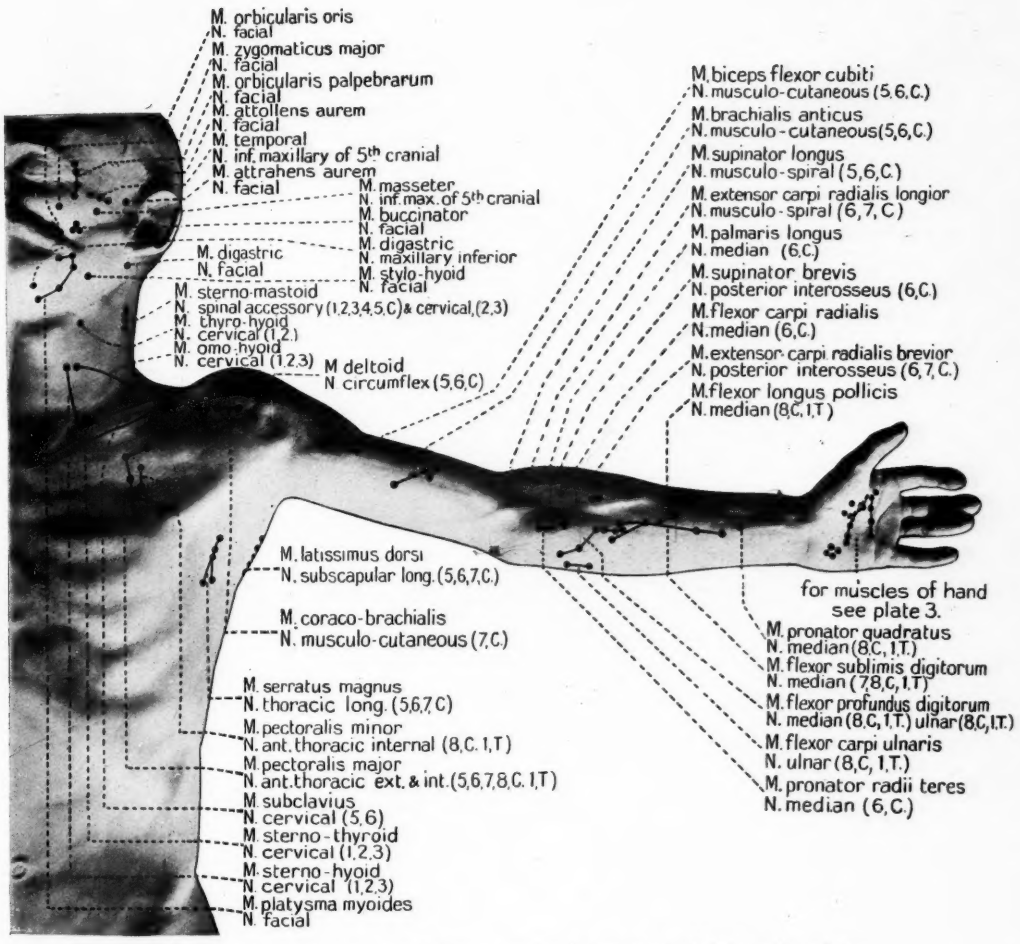
| | | | | | |
|---|---|---|---|---|---|
| Palmaris longus ... ... ... | Median | 6, C. | 1 | Deep surface, upper third | Plate 27 |
| Flexor carpi ulnaris ... ... | Ulnar | 8, C. 1, T. | 2 | Deep surface, upper third | Plates 27, 28 |
| Flexor sublimis digitorum ... | Median | 7, 8, C. 1, T. | 5 | Deep surface, middle two fourths | Plates 27, 28 |
| Flexor profundus digitorum ... | Median and ulnar | 8, C. 1, T. | 6 | Superficial surface, upper third | Plates 27, 28 |
| Flexor longus pollicis ... ... | Median | 8, C. 1, T. | 2 | Superficial surface, upper third | Plates 27, 28 |
| Pronator quadratus ... ... | Median | 8, C. 1, T. | 1 | Deep surface, middle third | Plates 27, 28 |
| Supinator longus ... ... ... | Musculospiral | 5, 6, C. | 2 | Deep surface, upper third | Plate 27 |
| Extensor carpi radialis longior ... | Musculospiral | 6, 7, C. | 2 | Deep surface, upper third | Plate 27 |
| Extensor carpi radialis brevior ... | Posterior interosseous | 6, 7, C. | 2 | Deep surface, upper third | Plates 27, 28 |
| Extensor communis digitorum ... | Posterior interosseous | 7, C. | 3 | Deep surface, upper third | Plate 29 |
| Extensor minimi digiti ... ... | Posterior interosseous | 7, C. | 1 | Deep surface, upper third | Plate 29 |
| Extensor carpi ulnaris ... ... | Posterior interosseous | 7, C. | 2 | Deep surface, upper third | Plate 29 |
| Anconeus ... ... ... ... | Musculospiral | 7, 8, C. | 1 | Deep surface, middle third | Plate 29 |
| Supinator brevis ... ... ... | Posterior interosseous | 6, C. | 1 | Superficial surface, upper third | Plates 27, 28 |
| Extensor ossis metacarpi pollicis ... | Posterior interosseous | 7, C. | 2 | Superficial surface, upper fifth | Plate 29 |
| Extensor primi internodii pollicis... | Posterior interosseous | 7, C. | 1 | Deep surface, upper third | Plate 29 |
| Extensor secundi internodii pollicis | Posterior interosseous | 7, C. | 1 | Superficial surface, upper fifth | Plate 29 |
| Extensor indicis ... ... ... | Posterior interosseous | 7, C. | 1 | Deep surface, upper fifth | Plate 29 |
| Abductor pollicis ... ... ... | Median | 6, 7, C. | 1 | Deep surface, upper third | Plates 27, 28 |
| Opponens pollicis ... ... ... | Median | 6, 7, C. | 1 | Deep surface, upper third | Plates 27, 28 |
| Flexor brevis pollicis ... ... | Median and ulnar | 6, 7, 8, C. | 2 | Superficial surface, upper third | Plates 27, 28 |
| Adductor obliquus pollicis ... | Ulnar | 8, C. | 2 | Deep surface, inner fifth | Plates 27, 28 |
| Adductor transversus pollicis ... | Ulnar | 8, C. | 1 | Deep surface, inner fifth | Plates 27, 28 |
| Abductor minimi digiti ... ... | Ulnar | 8, C. | 2 | Deep surface, upper third | Plates 27, 28 |
| Flexor brevis minimi digiti ... | Ulnar | 8, C. | 1 | Superficial surface, upper third | Plates 27, 28 |
| Opponens minimi digiti ... ... | Ulnar | 8, C. | 1 | Deep surface, upper third | Plates 27, 28 |
| Lumbricales ... ... ... | Ulnar | 8, C. | 2 | Deep surface, upper third | Plates 27, 28 |
| | Median | 6, 7, C. | 3 | Superficial surface, upper third | |
| Interossei ... ... ... ... | Ulnar | 8, C. | 7 | Palmar surface, upper fifth | Plates 27, 28 |
| Tensor fasciae femoris ... ... | Superior gluteal | 4, 5, L. 1, S. | 1 | Deep surface, middle third | Plates 30, 32 |
| Sartorius ... ... ... ... | Anterior crural | 2, 3, 4, L. | 7 | Deep surface, upper half | Plates 30, 33 |
| Rectus femoris ... ... ... | Anterior crural | 2, 3, 4, L. | 4 | Deep surface, upper half | Plate 30 |
| Vastus externus ... ... ... | Anterior crural | 2, 3, 4, L. | 5 | Superficial surface, upper third | Plates 30, 32 |
| Vastus internus ... ... ... | Anterior crural | 2, 3, 4, L. | 6 | Superficial surface, middle third | Plates 30, 33 |
| Crureus ... ... ... ... | Anterior crural | 2, 3, 4, L. | 4 | Superficial surface, upper third | Plates 30, 32 |
| Gracilis ... ... ... ... | Obturator | 3, 4, L. | 2 | Deep surface, upper third | Plates 30, 33 |
| Pectineus ... ... ... ... | Anterior crural | 2, 3, 4, L. | 1 | Superficial surface, upper third | Plates 30, 33 |
| Adductor longus ... ... ... | Obturator | 3, 4, L. | 4 | Deep surface, middle third | Plates 30, 33 |
| Adductor brevis ... ... ... | Obturator | 3, 4, L. | 2 | Superficial surface, upper third | Plates 30, 33 |
| Adductor magnus ... ... | Obturator | 3, 4, L. | 4 | Anterior surface, upper fourth | Plates, 31 33 |
| | Great sciatic | 4, 5, L. | 3 | Posterior surface, middle third | |
| Gluteus maximus ... ... ... | Inferior gluteal | 5, L. 1, 2, S. | 5 | Deep surface, middle third | Plates 31, 32 |
| Gluteus medius ... ... ... | Superior gluteal | 4, 5, L. 1, S. | 5 | Deep surface, middle third | Plates 31, 32 |
| Gluteus minimus ... ... ... | Superior gluteal | 4, 5, L. 1, S. | 3 | Superficial surface, junction of upper and middle thirds | Plates 31, 32 |

| Muscle | Nerve supply | Origin from segments of spinal cord | Number of points of entry into muscle | Place of entry into muscle | Relation to surface of body |
|---|---|---|---|---|---|
| Pyriformis | Sacral plexus | 1, 2, S. | 1 | Anterior surface, inner third | Plates 31, 32 |
| Obturator internus | Sacral plexus | 1, 2, 3, S. | 1 | Superficial intra pelvic surface, near small sciatic notch | Plates 31, 32 |
| Gemellus superior | Sacral plexus | 1, 2, 3, S. | 1 | Superficial surface, junction of inner and middle thirds | Plates 31, 32 |
| Gemellus inferior | Sacral plexus | 5, L. 1, S. | 1 | Deep surface, middle third | Plates 31, 32 |
| Quadratus femoris | Sacral plexus | 5, L. 1, S. | 1 | Deep surface, junction of inner and outer two thirds | Plates 31, 32 |
| Obturator externus | Obturator | 3, 4, L. | 1 | Deep surface, near anterior edge of obturator foramen | Plates 31, 32 |
| Biceps flexor cruris | Great sciatic | 4, 5, L. 1, 2, 3, S. | 3<br>3 | Deep surface, middle third<br>Superficial surface, upper third | Plates 31, 32 |
| Semitendinosus | Great sciatic | 4, 5, L. 1, 2, 3, S. | 3 | Deep surface, middle third | Plates 31, 33 |
| Semimembranosus | Great sciatic | 4, 5, L. 1, 2, 3, S. | 3 | Deep surface, middle third | Plates 31, 33 |
| Tibialis anticus | Anterior tibial | 4, 5, L. 1, S. | 4 | Deep surface, upper half | Plates 30, 32 |
| Extensor proprius hallucis | Anterior tibial | 4, 5, L. 1, S. | 1 | Superficial surface, upper fifth | Plates 30, 32 |
| Extensor longus digitorum | Anterior tibial | 4, 5, L. 1, S. | 2 | Deep surface, upper half | Plates 30, 32 |
| Peroneus tertius | Anterior tibial | 4, 5, L. 1, S. | 1 | Deep surface, upper fourth | Plates 30, 32 |
| Gastrocnemius | Internal popliteal | 1, 2, S. | 5 | Deep surface, upper fifth | Plates 31, 32 |
| Soleus | Internal popliteal<br>Posterior tibial | 1, 2, S.<br>1, 2, S. | 2<br>3 | Superficial surface, upper fifth<br>Deep surface, middle third | Plates 31, 32, 33 |
| Plantaris | Internal popliteal | 4, 5, L. 1, S. | 1 | Deep surface, middle of fleshy belly | Plates 31, 32 |
| Popliteus | Internal popliteal | 4, 5, L. 1, S. | 1 | Deep surface, middle third | Plates 31, 32 |
| Flexor longus hallucis | Posterior tibial | 5, L. 1, 2, S. | 4 | Deep surface, middle two fourths | Plates 31, 32, 33 |
| Flexor longus digitorum | Posterior tibial | 5, L. 1, S. | 3 | Superficial surface, upper third | Plates 31, 33 |
| Tibialis posticus | Posterior tibial | 5, L. 1, S. | 2 | Superficial surface, upper third | Plates 31, 32, 33 |
| Peroneus longus | Musculocutaneous | 4, 5, L. 1, S. | 4 | Deep surface, upper half | Plates 30, 32 |
| Peroneus brevis | Musculocutaneous | 4, 5, L. 1, S. | 3 | Superficial surface, upper half | Plates 31, 32 |
| Extensor brevis digitorum | Anterior tibial | 4, 5, L. 1, S. | 1 | Deep surface, upper third | Plates 30, 32 |
| Abductor hallucis | Internal plantar | 5, L. 1, S. | 1 | Deep surface, upper third | Plate 34 |
| Flexor brevis digitorum | Internal plantar | 5, L. 1, S. | 3 | Deep surface, upper third | Plate 34 |
| Abductor minimi digiti | External plantar | 1, 2, S. | 1 | Deep surface, upper fifth | Plate 34 |
| Flexor accessorius | External plantar | 1, 2, S. | 1 | Superficial surface, upper fifth | Plate 34 |
| Lumbricales | Internal plantar<br>External plantar | 5, L. 1, S.<br>1, 2, S. | 4 | Deep surface, upper fifth | Plate 34 |
| Flexor brevis hallucis | Internal plantar | 5, L. 1, S. | 2 | Superficial surface, middle third | Plate 34 |
| Adductor obliquus hallucis | External plantar | 1, 2, S. | 1 | Deep surface, upper third | Plate 34 |
| Adductor transversus hallucis | External plantar | 1, 2, S. | 1 | Deep surface, middle third | Plate 34 |
| Flexor brevis minimi digiti | External plantar | 1, 2, S. | 1 | Deep surface, middle third | Plate 34 |
| Interossei dorsal and plantar | External plantar | 1, 2, S. | 7 | Plantar surface, upper fifth | Plate 34 |



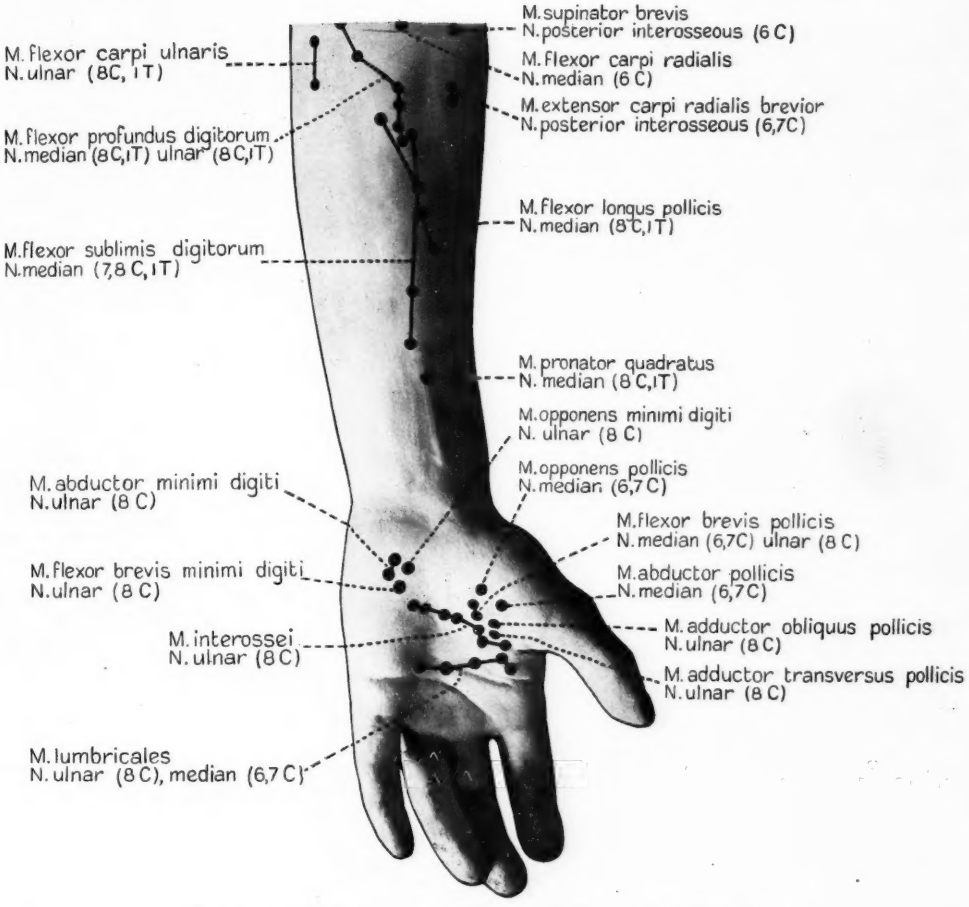

View of cast of trunk of living male from left side showing motor points.

(Prepared in the Anatomy Department of University of Aberdeen.)

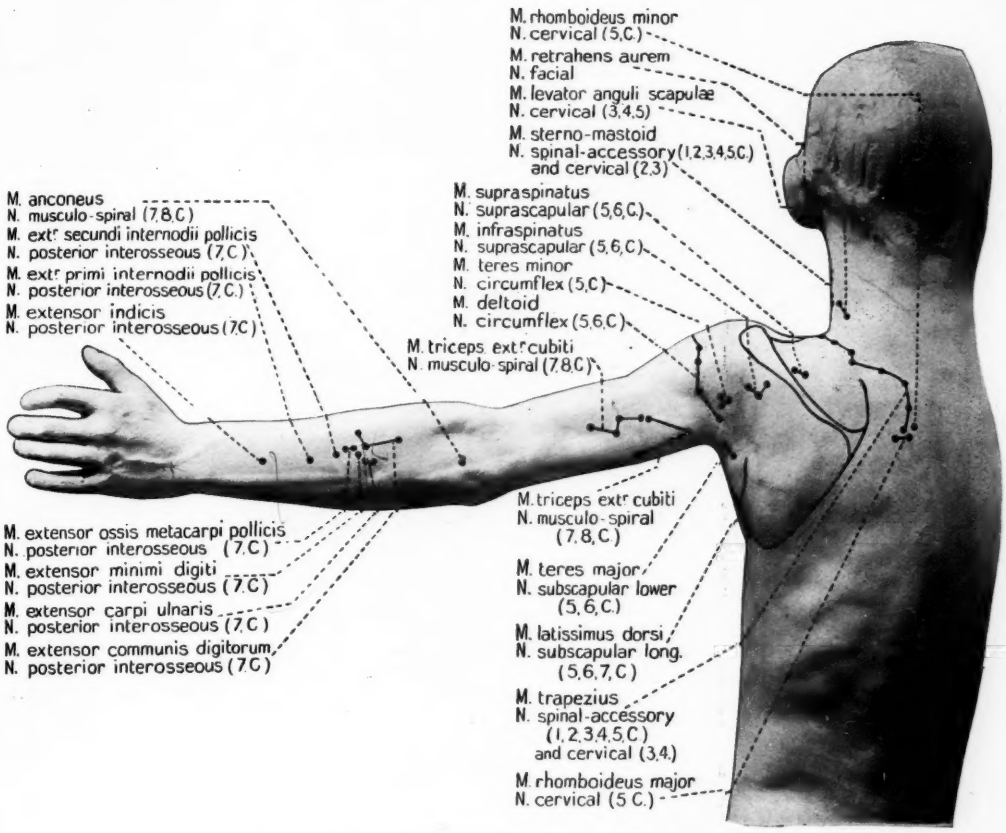



View of cast of left side of trunk and upper extremity from front showing motor points.

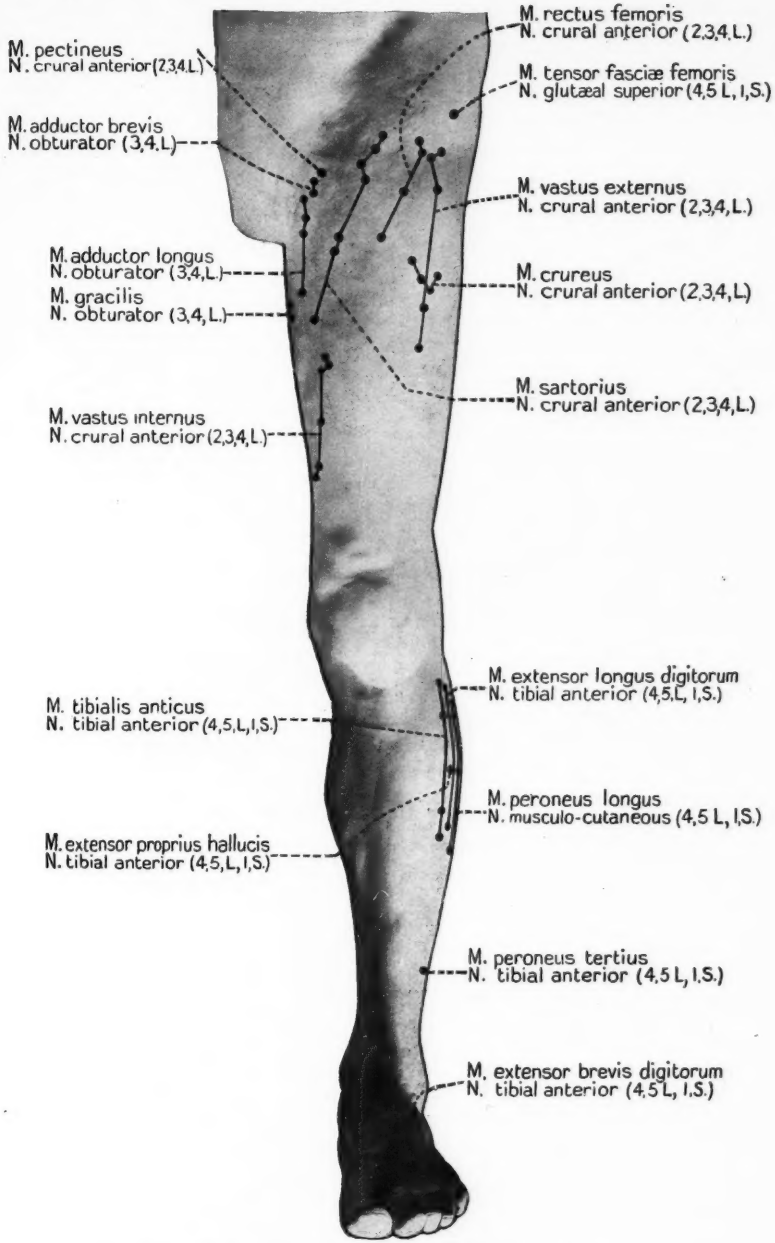
(Prepared in the Anatomy Department of University of Aberdeen.)


M. supinator brevis
N. posterior interosseous (6 C)
M. flexor carpi ulnaris
N. ulnar (8C, 1T)
M. flexor carpi radialis
N. median (6 C)
M. extensor carpi radialis brevior
N. posterior interosseous (6,7C)
M. flexor profundus digitorum
N. median (8C,1T) ulnar (8C,1T)
M. flexor longus pollicis
N. median (8C,1T)
M. flexor sublimis digitorum
N. median (7,8 C, 1T)
M. pronator quadratus
N. median (8C,1T)
M. opponens minimi digiti
N. ulnar (8 C)
M. opponens pollicis
N. median (6,7 C)
M. abductor minimi digiti
N. ulnar (8 C)
M. flexor brevis pollicis
N. median (6,7C) ulnar (8 C)
M. abductor pollicis
N. median (6,7C)
M. flexor brevis minimi digiti
N. ulnar (8 C)
M. adductor obliquus pollicis
N. ulnar (8 C)
M. interossei
N. ulnar (8 C)
M. adductor transversus pollicis
N. ulnar (8 C)
M. lumbricales
N. ulnar (8 C), median (6,7 C)

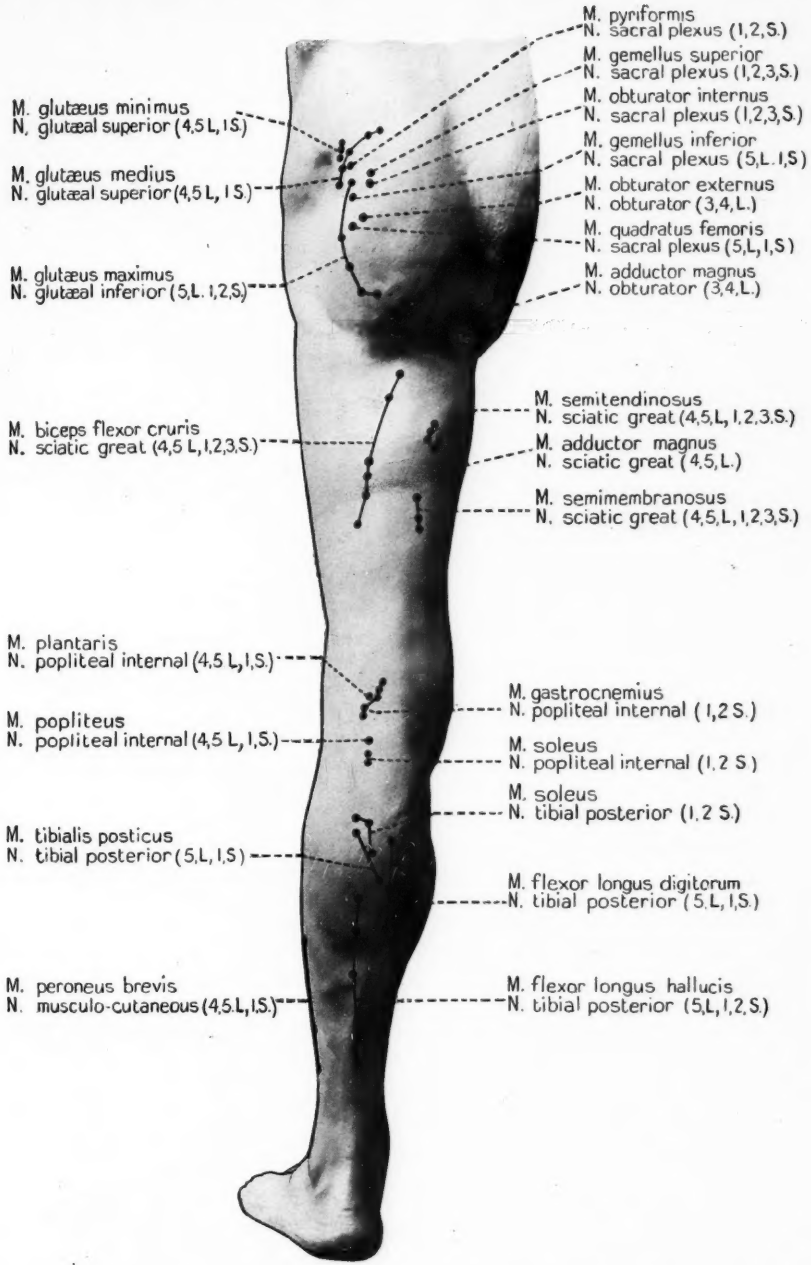
View of cast of left fore-arm and hand from front showing motor points.
(Prepared in the Anatomy Department of University of Aberdeen.)



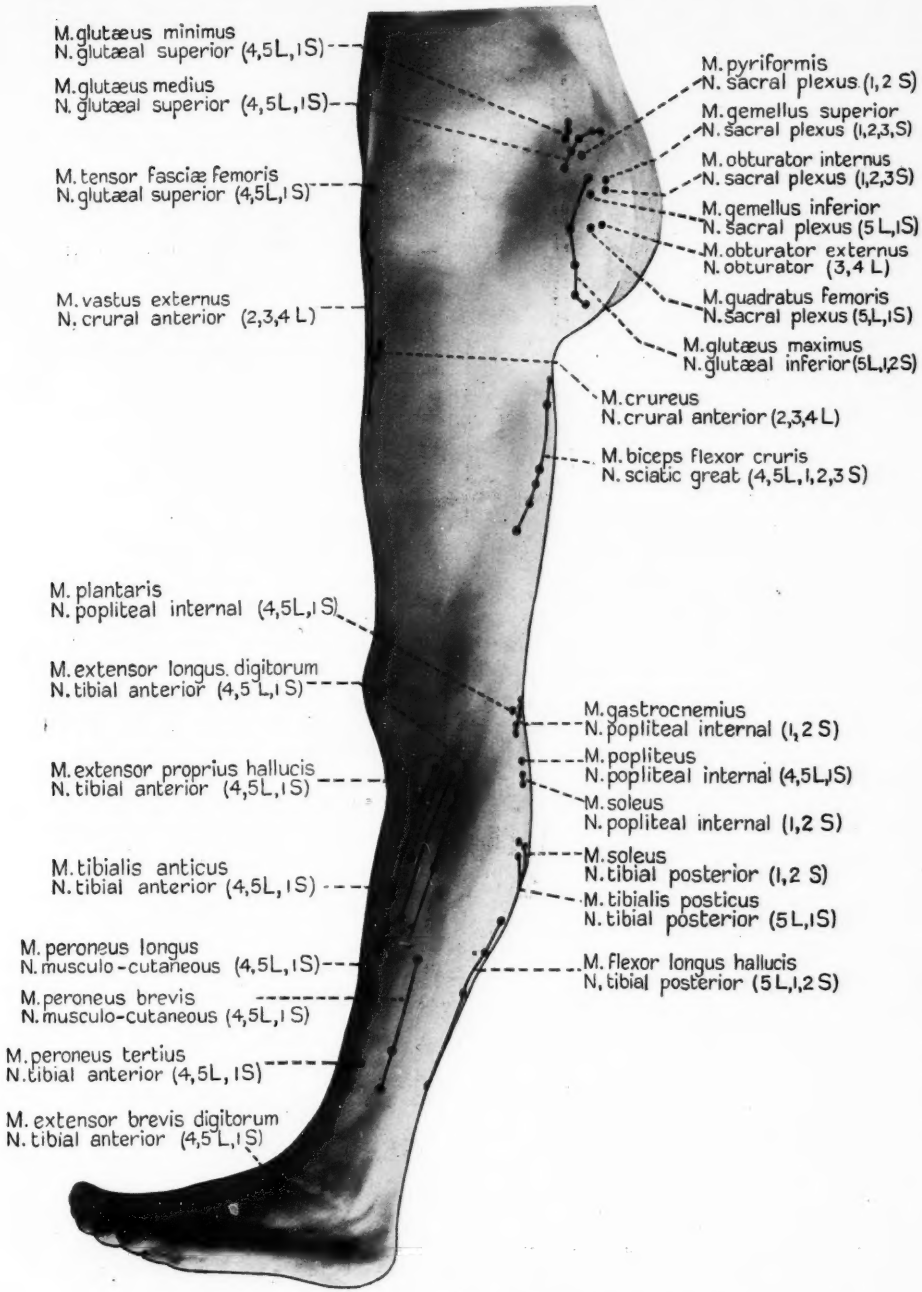

View of cast of left side of trunk and upper extremity from behind showing motor points.
(Prepared in the Anatomy Department of University of Aberdeen.)



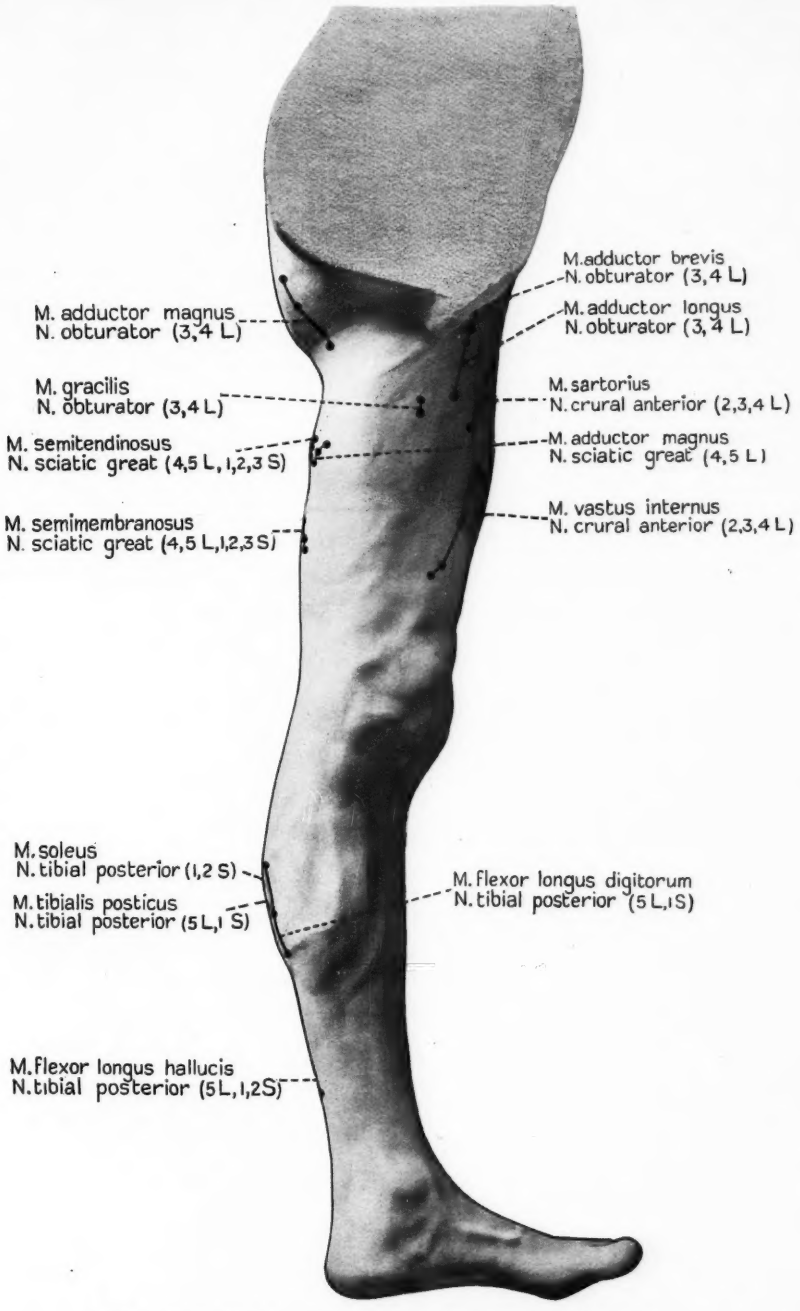

View of cast of left lower extremity from front showing motor points.
(Prepared in the Anatomy Department of the University of Aberdeen.)



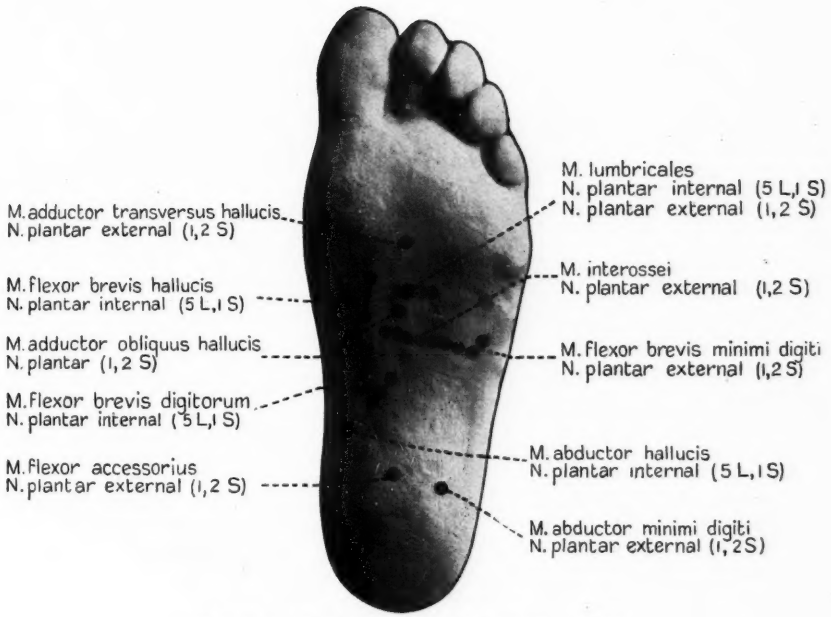

View of cast of left lower extremity from back showing motor points.
(Prepared in the Anatomy Department of University of Aberdeen.)




View of cast of left lower extremity from outside showing motor points.
(Prepared in the Anatomy Department of University of Aberdeen.)


M. adductor magnus
N. obturator (3,4 L)
M. gracilis
N. obturator (3,4 L)
M. semitendinosus
N. sciatic great (4,5 L, 1,2,3 S)
M. semimembranosus
N. sciatic great (4,5 L,1,2,3 S)
M. soleus
N. tibial posterior (1,2 S)
M. tibialis posticus
N. tibial posterior (5 L,1 S)
M. flexor longus hallucis
N. tibial posterior (5 L,1,2 S)
M. adductor brevis
N. obturator (3,4 L)
M. adductor longus
N. obturator (3,4 L)
M. sartorius
N. crural anterior (2,3,4 L)
M. adductor magnus
N. sciatic great (4,5 L)
M. vastus internus
N. crural anterior (2,3,4 L)
M. flexor longus digitorum
N. tibial posterior (5 L,1 S)

View of cast of left lower extremity from inside showing motor points.
(Prepared in the Anatomy Department of University of Aberdeen.)


M. adductor transversus hallucis
N. plantar external (1,2 S)
M. flexor brevis hallucis
N. plantar internal (5 L,1 S)
M. adductor obliquus hallucis
N. plantar (1,2 S)
M. flexor brevis digitorum
N. plantar internal (5 L,1 S)
M. flexor accessorius
N. plantar external (1,2 S)
M. lumbricales
N. plantar internal (5 L,1 S)
N. plantar external (1,2 S)
M. interossei
N. plantar external (1,2 S)
M. flexor brevis minimi digiti
N. plantar external (1,2 S)
M. abductor hallucis
N. plantar internal (5 L,1 S)
M. abductor minimi digiti
N. plantar external (1,2 S)

View of cast of sole of left foot showing motor points.

(Prepared in the Anatomy Department of University of Aberdeen.)

In making this investigation I wish to acknowledge the assistance given by Mr William Banbury, of the School of Art, Aberdeen, in making the cast which is figured in the Plates and I particularly desire to make mention of the great interest and help rendered by Mr G. O. Thornton, B.A., LL.B., Student of Medicine in this University, especially in the making of the special dissection and in transferring the motor points to the surface of the casts.

I wish, also, to thank Mr George Milne, artist, of the firm of Messrs George Robb, Lithographers, Adelphi, Aberdeen, for the great care he bestowed in connection with the photographing and lettering of the casts.

In the plates the black dots indicate motor points and the black lines indicate groups of motor points.

Copies of the casts marked and lettered in black and red (£13. 13*s*. per set) may be had on application to Messrs Robb, Lithographers, Adelphi, Aberdeen, N.B.

# A CASE OF PARTIAL TRANSPOSITION OF THE MESOGASTRIC VISCERA

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## INTRODUCTION

THE case here recorded is an example of a very rare type of partial heterotaxy, viz., one in which the stomach, duodenum, spleen and pancreas only are involved.

## CLINICAL HISTORY

The patient was a boy of 13 who died of acute septico-pyaemia resulting from osteomyelitis of the second left metatarsal bone. Clinically the liver was found to be distinctly enlarged, but the heterotaxy was entirely unsuspected during life.

## POST-MORTEM EXAMINATION

The principal lesion present was pyaemic infarction of the lungs. Both organs contained numerous haemorrhagic infarcts of various sizes, the larger especially showing central suppurative softening.

The condition of partial heterotaxy was at once evident on inspection, *in situ*, of the abdominal viscera. The liver was obviously much enlarged, the left lobe being quite as prominent as the right. The stomach was completely transposed, but was otherwise morphologically normal. The fundus lay to the right of the middle line, immediately under the right lobe of the liver, and in relation to it was a bunch of spleens of various sizes. The duodenum passed from the pylorus upwards and to the left, turned acutely downwards, and then to the right. Thereafter it passed upwards, and once more to the left. The pancreas, which appeared greatly shortened, arose from the duodenum at the junction of the first and second parts as above described. It passed almost directly upwards and terminated in the region of the cardiac orifice of the stomach, to which it was firmly adherent. Its total length was slightly under three inches.

None of the other viscera, either thoracic or abdominal, were transposed. The relatively large size of the left lobe of the liver (it was almost as big as the

right) was not found to be associated with any evidence of heterotaxy of that organ.

The stomach, duodenum, spleen and pancreas were removed *en masse* and preserved for subsequent dissection.

## DETAILED DESCRIPTION OF THE SPECIMEN

*Stomach.* The stomach, although lying entirely beneath the liver, exhibits a striking resemblance in shape to the ordinary, moderately contracted, post-mortem stomach, save that it is reversed, the lesser curvature being to the left, the greater curvature to the right. The fundus is well developed. There is a well marked incisura angularis in the lesser curvature rather more than two-thirds of the distance between the cardiac orifice and the pylorus, and there is a more or less definite pyloric antrum on the greater curvature. The pyloric portion exhibits the usual contraction for a distance of 3 cm. from the pylorus.

*Duodenum.* A statement of the course of the duodenum has been made in the account of the post-mortem examination, and from this it appears that it took the form of a double loop. The concavity of the first loop, very narrow owing to the close apposition of the two limbs in the recent condition, was directed downwards and to the right, and, being in association with the pancreas, represents the ordinary concavity of the first and second portions reversed. The second loop, the concavity of which was directed upwards and to the left, was produced by the third portion of the duodenum passing in more or less normal fashion upwards and to the left to the duodeno-jejunal junction. The first and second portions of the duodenum are in fact reversed, and the transition to the normal arrangement takes place at the junction of the second and third portions. The compressed double loop form of the duodenum is the result.

The body level of the pylorus and the exact position of the duodeno-jejunal junction relative to the posterior abdominal wall were not ascertained.

As a result of this arrangement there is an apparent shortening of the first portion of the duodenum, which extends to the left of the pylorus for about 3 cm. only, just sufficient to allow of the downward bend to the second portion without kinking. The second portion measures about 8 to 9 cm. in length, and the total length of the duodenum is about 24 cm. An examination of the interior of the duodenum lends support to the view that the first portion is shortened. Valvulae conniventes are present to within 1·3 cm. of the pylorus, and the bile papilla (papilla major) is situated at a distance of 5 cm. from the pylorus. The distance of the papilla major from the pylorus varies, according to a number of authors, from 8 to 12 cm. in the adult, and valvulae conniventes do not, as a rule, appear in the normal first portion of the duodenum, i.e., for a distance of about 5 cm. from the pylorus in the adult. The present specimen, however, is from a subject aged 13, and moreover has been preserved by the

Kaiserling process since 1911, so that no doubt some contraction has taken place. On the other hand, as discounting these factors to a considerable extent, the position of the papilla minor relative to the papilla major is of importance. It is situated 2·2 cm. on the pyloric side of the papilla major, the normal variation, according to the same authors, being from 2 to 4 cm. in the adult. Both the papillae are situated on the posterior wall of the second portion o. the duodenum, and their position relative to the circumference of the gut is the reverse of that normally found, the papilla minor being situated 1·2 cm. to the *right* of the papilla major. The papilla major has well marked "hood" and "frenulum" valvulae conniventes; the papilla minor, much less prominent, has a frenulum but no hood.

In two other subjects of the same age (13) the various distances were found to be as follows: pylorus to papilla major, 5·6 cm. and 6·5 cm.; papilla major to papilla minor, 1·5 cm. to 2·5 cm.; pylorus to first vulvula connivens, 2·5 cm. As the duodena from which these measurements were taken had been similarly preserved in formalin, there remains a considerable probability that there is an actual shortening of the first part of the duodenum in the specimen under discussion.

*Pancreas.* The pancreas is not divisible into head, neck and body, the whole organ being compressed into one mass measuring 7·1 cm. greatest length, by 3·7 cm. greatest breadth. The length of the pancreas is stated in the notes of the post-mortem examination to have been slightly under 3 inches. We have here, therefore, an indication that no serious amount of contraction has since taken place. The long axis lies almost at right angles to the first part of the duodenum, and the blunt extremity is adherent to a number of lymphatic glands matted together on the posterior aspect of the region of the cardiac orifice of the stomach. The lower end of the organ lies behind the first loop formed by the duodenum, and extends more to the right than to the left of its descending portion. It is also closely adherent to the short first portion of the duodenum, and, for a little way, to the lesser curvature of the stomach, coming here into intimate relationship with the bile duct, hepatic artery and portal vein. The pancreas is separated from the nearest spleen by a distance of 2·5 cm.

*Ducts of the Pancreas.* The main duct (Wirsung), commencing at the upper, blunt extremity, runs downwards nearer to the right than the left border of the organ, bends slightly to the left at the level of the upper border of the first part of the duodenum, and continues downwards in a slightly curved course with the concavity forwards and to the right. Increasing gradually in size it joins the common bile duct as it enters the wall of the duodenum, the junction being effected on the posterior aspect and slightly on the right side of the bile duct. From the point at which the main duct bends to the left the accessory duct (Santorini), continuing the direction of the upper part of the main duct, passes vertically through the right side of the portion of the pancreas adhering to the pyloric region, and opens into the duodenum at the papilla

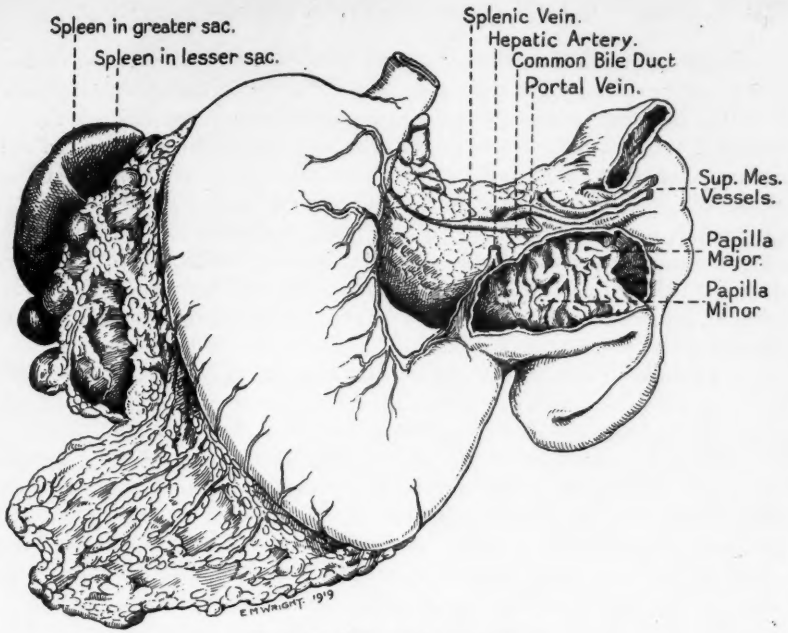


Fig 1. Ventral aspect of specimen.

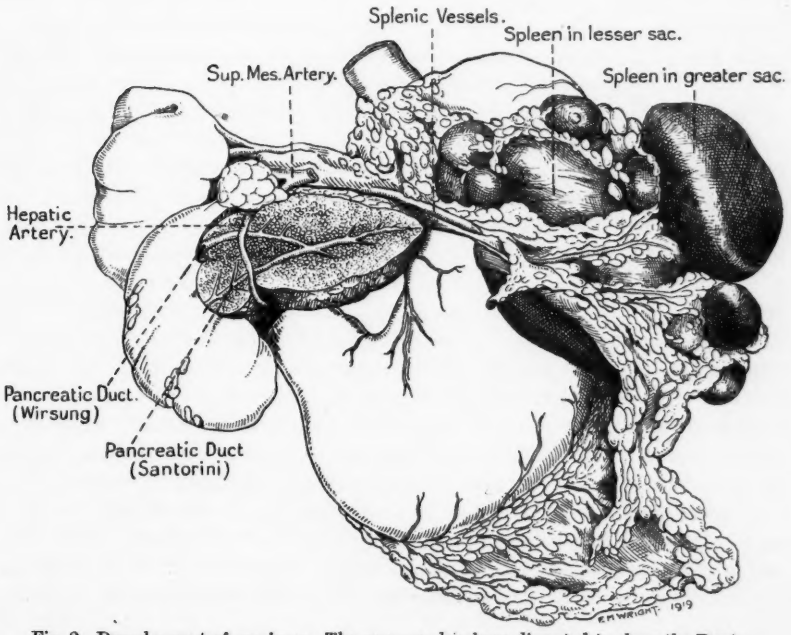


Fig. 2. Dorsal aspect of specimen. The pancreas has been dissected to show the Ducts.

minor. Though varying slightly in size and distinctly narrower as it approaches the gut than at its origin from the main duct, the accessory duct is quite pervious, and readily allows a stylet to be passed through it. Dissected from behind it appears to be the direct continuation of the duct coming from the extremity of the organ, while the actual continuation of the duct of Wirsung apparently springs at an angle from its anterior aspect.

The tributary of the accessory duct, usually described as passing from the lower part of the head of the pancreas upwards in front of the duct of Wirsung, does not appear to be present. Two small tributaries are seen from behind entering the left side of the accessory duct, but neither of these could be traced beyond the line of the main duct.

It would appear therefore that the pancreas shares the incomplete transposition of the duodenum so far as final position is concerned, though developmentally the transposition may be considered to be complete in the sense that the ventral pancreas has rotated with the bile duct to the left instead of to the right. The picture of finally complete transposition could easily be produced in the specimen before us by turning the duodenum more over to the left, and rotating the pancreas to the right behind the body of the stomach. The ducts of the pancreas would then assume their normal positions reversed, and the relative positions of the papillae would similarly become the exact reverse of normal, the minor taking a position ventral to but on the right of the major. It seems probable that this has been prevented by the third portion of the duodenum assuming what is practically its normal position, and so hindering the complete turning over to the left of the second portion.

*Spleen.* The spleen is divided into thirteen separate portions, two large and eleven small, which lay in the right hypochondrium below the right lobe of the liver. The two larger spleens, measuring respectively 9·2 cm. by 5·6 cm. and 6·1 cm. by 4·1 cm., are closely applied to the greater curvature of the stomach and attached to it by folds of gastro-splenic omentum. The smaller of the two with concave gastric and convex parietal surfaces, lies above and to the right of the larger, and presents the usual relation to the peritoneum, its peritoneal covered surface being visible beyond the greater curvature of the stomach, i.e., in the greater sac. The larger of the two has its peritoneal relations reversed, the peritoneal covered surface being in relation to the posterior surface of the stomach, i.e., in the lesser sac and shut off from the greater sac by the continuation downwards, as the great omentum, of the gastro-splenic omentum attached to the other.

The peritoneal connection of this spleen is more directly with the posterior wall of the lesser sac than with the greater curvature of the stomach, i.e., it is attached to the dorsal mesogastrium dorsal to the smaller spleen, which lay in the greater sac. Its shape is of considerable interest as throwing light upon the factors that probably mould the normally situated organ. The vessels enter the dorsal aspect at a distinct hilum, and the whole dorsal surface, applied to the posterior wall of the lesser sac and in relation, no doubt, to

the right kidney, is markedly concave. The gastric surface on the other hand, though directly applied to the greater curvature and posterior aspect of the stomach, does not appear to be much impressed thereby. It is distinctly convex in all directions, with a slight concavity in the middle. It would appear therefore that the natural growth of the spleen around its entering vessels is to some extent responsible for its final shape. This conclusion is strengthened by an examination of the smaller spleens, which exhibit various stages of the formation of a concave surface on the side of the entering vessels and a convex surface on the other side. This deduction from the appearance of the spleens seems to be justified in spite of the fact that the organs were not hardened *in situ*, and it is reasonable to suppose that the moulding action of the stomach on a normally situated spleen is greatly helped by the natural formation of a concavity on the side of the hilum.

It is further interesting to note that there is a slight notching of the right border of the large spleen in the lesser sac: were the stomach and the dorsal mesogastrium reversed so as to occupy their normal position this border would become the ventral border of a normally situated spleen. None of the other spleens show any sign of notching.

The eleven small spleens, varying in greatest diameter from 4·5 mm. to 19 mm., lie grouped around the larger ones, seven in the greater sac and four in the lesser.

*Liver.* The general position and appearance of the liver have been described in the account of the post-mortem examination. Its most striking feature is the large size of the left lobe, which apparently extended well into the left hypochondrium, though not so far as to occupy the position of the normally situated spleen. The right lobe, extending into the right hypochondrium, is considerably reduced in vertical depth, being flattened from above downwards by the presence of the subjacent, well developed stomach. The visceral surface presents the usual arrangement of fissures as in a normal right sided organ. The gall bladder lies in a shallow fossa to the right of the umbilical fissure, which is converted by a thick *pons hepatis* into a tunnel giving passage to the ligamentum teres.

The bile passages are normally arranged, and the common bile duct lies in front of and to the right of the hepatic artery in the transverse fissure. As it passes downwards it comes to lie in what has been the free edge of the lesser omentum, and taking up a position to the left of the hepatic artery, it passes behind the short first portion of the duodenum. Thereafter, partially surrounded by processes of the main part of the pancreas, it reaches the posterior wall of the second portion, where it is joined by the main duct of the pancreas before finally piercing the wall of the gut.

*Peritoneal Relations.* Owing to the presence of adhesions the exact position and relations of the foramen of Winslow were not observed, but there is evidence of a well formed lesser sac, there being only one small adhesion between the posterior surface of the stomach near the cardiac end of the lesser

curvature and the largest of the spleens. The relation of the spleens to the lesser sac has already been described, and the continuity of the gastro-splenic omentum with a well formed great omentum mentioned.

The whole of the duodenum was bound down to the posterior abdominal wall, the first and second portions by their connections with the pancreas, and the third, in the ordinary way, being crossed by the superior mesenteric vessels in their course to the mesentery.

*Blood Vessels.* The coeliac axis artery divides into the coronary and splenic only. The coronary, running upwards behind the pancreas, supplies a few branches to its upper part. Reaching the lesser curvature at the cardiac orifice, it runs along it in the usual way, dividing into two parallel vessels of which the anterior and larger anastomoses with a pyloric branch of the hepatic artery.

The splenic artery runs to the right behind the pancreas for a short distance, and then behind the peritoneum of the posterior wall of the lesser sac to break up into a number of branches for the various spleens. A few branches reach the greater curvature of the stomach, constituting in the usual way vasa brevia and the gastro-epiploic artery. The main splenic artery is only slightly tortuous as it passes behind the first large spleen, and none of the branches to the individual spleens show any tortuosity at all.

The hepatic artery is derived, not from the coeliac axis, but from the superior mesenteric through an enlarged pancreatico-duodenal arch passing over the back of the lower end of the pancreas. There is no obvious anastomotic branch between the hepatic artery thus formed and the coeliac axis or its branches. As it reaches the first part of the duodenum, where it lies to the right of the common bile duct, the hepatic artery gives off a small pyloric branch, while a branch to the greater curvature of the stomach (to complete the gastro-epiploic anastomosis) springs from the vessel as it lies on the back of the pancreas.

The superior mesenteric artery takes a normal course across the front of the third part of the duodenum, but does not lie behind the pancreas, which is entirely to its right. It gives off the hepatic artery as already described.

The portal vein is formed on the left side of the lower part of the pancreas by the junction of the superior mesenteric vein coming from below and the left, and the splenic vein from above and the right. The termination of the inferior mesenteric vein has not been preserved, but in all probability it joined the superior mesenteric. The splenic vein runs in front of and partly embedded in the pancreas, receiving in its course pancreatic tributaries and the coronary vein. The portal vein so formed turns forward in the left side of the pancreas to reach the back of the first part of the duodenum. Here it lies on the left and partly in front of both the common bile duct and the hepatic artery, but at the portal fissure it is found occupying its usual position behind these structures. In this situation it describes a curve to the right before dividing into its two terminal branches, but otherwise it is quite normal in its distribu-

tion. The right and left portal branches are of nearly equal size, and the ligamentum teres and ligamentum venosum show the usual relation to the left branch.

## DISCUSSION

We have before us, therefore, a case of incomplete heterotaxy of the mesogastric organs, and the question of the causation of this rare condition presents itself for discussion(2). It should first be noted that incomplete heterotaxy, apart from abnormalities of the great thoracic vessels only, is much rarer than the complete variety. More than 300 cases of the latter have actually been recorded, and Arneill(1) has demonstrated that many are observed clinically and escape record. He has further shown that the proportion of clinical to post-mortem cases has completely altered. Gruber(5) had collected seventy-nine cases recorded up to 1865, only five or six of which had been observed in life, and Arneill himself, in 1902, had records of forty-four cases, thirty-eight of which were clinical. Of Gruber's seventy-nine cases seventy-one were complete, and the remaining eight were abdominal only and all incomplete. So far as we can ascertain, no case has yet been recorded of transposition of all the abdominal viscera unaccompanied by transposition of the thoracic viscera also. We have been unable to trace all the examples of incomplete abdominal heterotaxy of which mention has been noted during a search through the literature of the subject, but three illustrative cases may be quoted.

In 1894 Launay(7) recorded the discovery in a woman, who died of cancer of the pancreas, of partial transposition very similar to that here described, but with the liver also transposed. He referred to another and similar case recorded by Debouie(4) in 1857, making special note of the fact that in the latter the three parts of the duodenum were found to be "normal." Debouie himself describes the duodenum as having its three portions situated in the exact reverse of the normal position, the concavity of the curve formed by them being directed to the right. As the liver in this case was not transposed, the relative positions of the organs were almost exactly the same as in the present example. The spleen was represented by a reddish spherical tubercle about the size of a cherry stone, and attached to the fundus of the stomach in the right hypochondrium. This case was discovered in a child born a little before term. The spleen in Launay's case consisted of two portions, together about the volume of one normal spleen, situated in the right hypochondrium and attached to the tail of the pancreas and the stomach.

In 1854 Allen Thomson(9) wrote an account of a much more curious and interesting condition where all the organs, thoracic and abdominal, *with the exception of stomach, duodenum, pancreas and spleen* were transposed, the exact opposite of the case here described. The stomach, normally situated, lay beneath the left lobe of the transposed liver, and the duodenum had a doubly looped course almost the reverse of that here described, passing finally to the right to its junction with the transposed jejunum. The pancreas occupied

a position departing only slightly from that of the natural organ in consequence of the deviation of the duodenum, and the spleen, though situated lower than usual, was otherwise normal.

It appears that a definite distinction must be made as regards probable causation between complete and incomplete heterotaxy. The former must be dated back at least to the segmentation of the ovum(3), whereas the latter is more probably conditioned by subsequent anomalies in the development either of a median organ which later becomes asymmetrical, or of originally symmetrical, paired bilateral structures one of which constantly disappears or has a different developmental history from the other. Examples are seen in the cases of partial transposition involving the heart and great vessels. Paired organs which normally have no connection with each other developmentally, e.g. reproductive glands, kidneys, suprarenals, cannot conceivably be transposed except as part of a general transposition of all the organs. In this connection it is interesting to quote the following paragraphs from Allen Thomson:

> It is right to state that in attributing the origin of certain malformations to some original peculiar constitution of the germ, and of others to changes and injuries which are ascertained to occur in the progress of development, to the latter of which divisions the malformation of transposition appears most probably to belong, it is by no means intended to be denied that there may in these cases also be a nisus or predisposition belonging to the germ originally and derived by it possibly like other qualities from hereditary transmission.
>
> In offering such explanation of the origin of malformations I do not profess entirely to discover their cause, but rather attempt to point out that part of the process of development with which they are most intimately and constantly connected.

In each case of partial transposition, therefore, a dynamic is to be sought to account for the more obvious changes, though of necessity the true explanation will only thus be thrown further back.

It is now generally believed that "the individual anlagen of an organism mutually influence one another during development so as to cause the formation of a normal organism" (Keibel(6)), and it seems reasonable to seek the determining condition of partial transposition in the growth of any structure which normally is not associated with the middle line in its development, particularly if there is reason to believe that bilateral rudiments of such a structure exist. The only structure that fulfills these conditions in connection with the mesogastrium is the ventral pancreas: the stomach itself, the duodenum, the liver and the dorsal pancreas are all median structures.

The bilateral origin of the ventral pancreas has been denied, on the ground that in the majority of human embryos studied at the period of its first appearance, an unpaired ventral pancreas is found, situated as a rule in the middle line, in the caudal angle between the hepatic diverticulum and the duodenum. On the other hand there are a number of embryological investigations on record which suggest the occasional presence of bilateral rudiments.

Now in complete heterotaxy the ventral pancreas will be transposed, and if the normally developing ventral pancreas be the right rudiment, then for

the transposed organ the left rudiment will develop, this as a result and as a part of the general mirror-image formation of the body. In a case of partial heterotaxy, on the other hand, involving the pancreas, though the left rudiment of the ventral pancreas will again develop, it will now be part of a local process only. It is suggested that the dynamic of such a partial case as the present, involving the organs of the mesogastrium, may be found in the survival of the left rudiment of the ventral pancreas instead of the right, as is believed usually to be the case.

The observed facts of the relative times at which the developmental happenings concerned occur are, at any rate, not opposed to the possibility which is suggested. The hepatic diverticulum appears in the middle line before the sagittal enlargement of the stomach is indicated, and the rudiment of the ventral pancreas associated with the hepatic diverticulum is already present in the earliest embryo in which the rotation of the stomach has been observed. It is suggested as a possibility that the side of the hepatic diverticulum on which the ventral pancreas develops is the side to which it will move, and that this in turn will affect the twisting of the stomach, and of course the dorsal mesogastrium and subsequently developed spleen. It does not follow that the liver will be affected, since it has already proceeded on its developmental path before the bending over of the bile duct takes place, and similarly the small intestine need not be affected beyond the local displacement due to the transposition of the duodenum. There is no reason why the twisting of the intestinal loop should be affected, as this is a separate phenomenon of later date. If the effect does not extend beyond the duodenum then it is likely that the duodenum itself will be shortened; where it is completely transposed as in Launay's case by doing away with the third portion, where the effect does not extend to the whole duodenum by shortening the first part, as in the present case.

If this hypothesis be correct then the case described by Allen Thomson appears as a remarkable instance of an anomaly within an anomaly. It must be explained as a partial transposition superimposed on a complete transposition, the result being the apparently normal situation of the mesogastric organs.

It should be pointed out that the relative position of the two papillae in the second portion of the duodenum furnishes evidence that the pancreas in the present case is, in fact, transposed; and it is also worth noting that according to Lewis (8) the rotation of the stomach is from the first greater at the pyloric than at the cardiac end.

Multiplicity of spleens has been noted as a common condition in transposition. So far as actual numbers go, the highest number on record (Otto, quoted by Testut) is twenty-three, and the next highest seven (recorded twice by Baillie and Cruveilhier). There were thirteen in the present instance.

## REFERENCES

(1) Arneill. "Clinical Observations on Congenital and Acquired Transposition of the Viscera." *Amer. Journ. Med. Sciences*, 1902, 124, 885.
(2) Ballantyne. *Manual of Antenatal Pathology and Hygiene.* Edinburgh, 1904, vol. II, chap. 30.
(3) Conklin. "The Cause of Inverse Symmetry." *Anat. Anzeiger*, 1903, 23, 577.
(4) Debouie. *Bull. de la Soc. anat. de Paris*, 1857, 2me Sér., 2, 59.
(5) Gruber. Quoted by Arneill.
(6) Keibel. "The Interdependence of the Various Developmental Processes." Keibel and Mall's *Manual of Embryology*, 1912, vol. II, chap. 20, p. 980.
(7) Launay. "Un Cas d'inversion isolée des organes du mésogastre antérieur et postérieur." *Bull. de la Soc. anat. de Paris*, 1894, 5me Sér., 8, 320.
(8) Lewis. "The Development of the Intestinal Tract, and Respiratory Organs." Keibel and Mall's *Manual of Embryology*, 1912, vol. II, chap. 17, pp. 330, 403, and 429.
(9) Allen Thomson. "Notice of the Dissection of a case of Lateral Transposition of the Viscera of the Thorax and Abdomen in a Man." *Glasgow Med. Journ.*, 1854, N.S. 1, 216.

# THE PRONEPHROS AND EARLY DEVELOPMENT OF THE MESONEPHROS IN THE CAT

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COMPARATIVELY few observations have been made on the early development of the excretory system in the Mammalia. The existence of a pronephros was first recorded in the rabbit and rat by Renson ('83), and later Janosik ('85) described pronephric canals in the rabbit. A more detailed investigation of the anterior end of the excretory organ (called by this author *mesonephros*) in the same animal has been given by Martin ('88), and a few observations were made by Rabl ('96) in 1896. The most complete accounts of the mammalian pronephros are those of Kerens ('07) in both the rabbit and the mole, and of Felix ('12), who has described in some detail both pro- and mesonephros in the human embryo. Embryos of the marmot have been studied by Janosik ('04), and van der Stricht ('13) has recorded the existence of a pronephros in an embryo of the bat, *Rhinolophus hipposideros*.

The anterior end of the organ which gives rise to the Wolffian duct shows varying stages of degeneration in different genera; the course of development is much abbreviated, and events follow each other with great rapidity. The correct interpretation of what takes place is therefore not easy, and whilst more knowledge of the conditions in other mammals is greatly needed, the exact significance of these rudimentary structures can only be appreciated after careful comparison with the corresponding parts of the organ in lower vertebrates.

Owing to the rapidity at which development takes place in early stages, a very complete and well preserved series of embryos is an essential factor for accurate observations. The series of cat embryos in the possession of Professor J. P. Hill, from which my investigations are taken, is an excellent one, and the embryos are mostly in a good state of preservation. I should like to express my gratitude to Professor Hill and to thank him for his kind criticism.

In stages possessing 17 to 35 somites and older, the sequence is a very close one, and moreover consists of many individuals of the same age. It is thus quite adequate for a study of the excretory system during this period. The number of embryos with 9 to 16 somites, during which time the Wolffian duct first makes its appearance, is smaller, and, though fairly complete, does not justify a definite and final conclusion as to the exact mode of origin of the duct at this early stage. The observations of these early stages were made from one

embryo of each of the stages with 8, 9, 10, and 12 somites, two embryos with 14, and two with 16 somites.

These investigations were begun in 1918 during my tenure of a research assistantship under the Department of Scientific and Industrial Research.

I am much indebted to Mr F. Pittock of University College for the beautiful microphotographs on plates XXXVI, XXXVII, and XXXVIII.

## DESCRIPTION OF STAGES

*8 to 10 somites.* The primordium of the excretory organ in the cat first appears in embryos with 8 to 10 somites. At this stage a central cavity is beginning to appear in the somites, and each one is united with the lateral plate by a narrow somitic stalk or intermediate cell mass. In the more cranial portion, that is opposite the first six somites, the somitic stalk appears to consist of two single layers of cells, separated by a lighter portion extending inwards from the coelom, with indications here and there of a definite lumen. More posteriorly the stalk increases in thickness and more definite cavities can be seen within it, although these never extend into the cavity of the somite itself.

At the anterior end of the 7th somite, almost simultaneously with the formation of the intermediate cell mass, the somatic wall of the latter, about midway between the somite and the lateral plate, becomes slightly thickened, and consists of two or three layers of cells which extend up dorsally towards the ectoderm. The thickening becomes very distinct between the 7th and 8th somites, and forms a marked swelling on the somatic side of the stalk; behind this level it gradually increases in size, becoming more prominent. Plate XXXV, fig. 1, shows the swelling in the region of the 8th somite. Although, perhaps most developed at the cranial end of the 9th somite (plate XXXV, fig. 2), the whole somatic wall of the stalk is much thickened throughout this somite, and at the end of the latter and opposite somite 10 (plate XXXVI, fig. 3) it extends out towards the ectoderm as a definite dorsal outgrowth, which is still well marked posterior to the segmented region of the embryo. Although at the cranial end, opposite somites 7 and 8, the swellings may be slightly more marked at some points than at others, no definite metamerism can be distinguished, the thickenings posteriorly forming a continuous ridge.

At the beginning of the 8th somite for a few sections, and again opposite the 9th, the intermediate cell mass becomes isolated from the somite, and is at the same time marked off from the lateral plate by a constriction; in a cross section through one of these points the mid-region of the stalk appears as a somewhat tubular structure, being composed of cells surrounding a latent lumen (plate XXXV, fig. 1 *a*).

Between the somites and again opposite the middle of each, from the level of the sixth somite backwards, a small portion of the coelom becomes partially cut off from the general body cavity just laterally to the somitic stalk. From

between the 8th and 9th somites backwards to the hinder end of the embryo this portion closes in to form a small vesicular chamber, lying immediately to one side of the thickened region of the intermediate cell mass (plate XXXV, fig. 2, *c.ch.*); in front of the 8th somite cranially this structure is less well developed, and opposite the 6th somite can hardly be distinguished. The cavity of the chamber may occasionally extend inwards into the intermediate cell mass.

12 *somites*. The central cavity of the somite is more distinct, and the hinder end of each is united with the lateral plate by the intermediate cell mass, whilst the mid-region of the somite is again connected with the latter by a few cells. Opposite the 6th somite a few cells extend up dorsally from the somatic layer of the stalk, but these disappear, and no thickening is present in the region of the 7th somite. Opposite the 8th and 9th, the middle portion of the stalk remains attached to the lateral plate in the form of a circular mass as in the last stage, its component cells surrounding a lightly staining area in which a central cavity may be distinctly visible (plate XXXV, fig. 4). From the 8th somite posteriorly, this mass increases in size, its somatic wall thickens and extends out towards the ectoderm. This thickening becomes gradually more conspicuous, continuing throughout somite 10 (plate XXXV, fig. 5), and forming opposite the 11th (plate XXXVI, fig. 6 *a*, 6 *b*) and beginning of the 12th somites a prominent solid outgrowth, which lies closely adjacent to the ectoderm, pressing the latter slightly outwards. For some distance behind the segmented region of the embryo, a well marked swelling is to be seen on the somatic side of the intermediate cell mass which is thick in this region. Except opposite the anterior part of the 9th somite, where the swelling appeared to be less marked, no segmentation could be distinguished.

The vesicular chambers, described in the last stage, are now much better developed. They are present opposite somites 10 (plate XXXV, fig. 5), 11 (plate XXXVI, fig. 6 *a*, 6 *b*), and 12, and continue behind the segmented region of the embryo as far back as the shortened primitive streak region or tail bud, forming a series of coelomic chambers, which are becoming separated off from the general body at intervals one behind the other. Some are larger than others, as for example opposite somite 10 (plate XXXV, fig. 5, *c.ch.*) where we find a well marked chamber with a wide central cavity lying ventro-laterally to the thickened portion of the somitic stalk. Fig. 7 *a* and *b* shows the condition near the hinder end of the embryo. I put forward the suggestion, which seems to me a probable one, that these structures represent vestigial pronephric chambers, each one communicating with the general coelom by a peritoneal funnel. In some places, as opposite somite 10, a distinct lumen can be seen passing in from the coelom all along the intermediate cell mass as far as the wall of the somite.

14 *somites*. The sections of this embryo are unfortunately rather oblique, thus making a correct interpretation of the swellings of the intermediate cell mass more difficult in the region of the 8th to the 10th somites on that side.

The pronephric ridge extends from the 8th somite posteriorly. The anterior portion, from the 8th to the mid-region of the 9th somite, is separated from the remainder by a gap of ·04 mm.; behind this gap the ridge extends continuously backwards, gradually increasing in thickness to the end of the 14th somite, marking the limit of the segmented region. Here and there a central cavity may be observed within it. Plate XXXVI, fig. 8, *p.r.* shows the ridge at the level of the 13th somite.

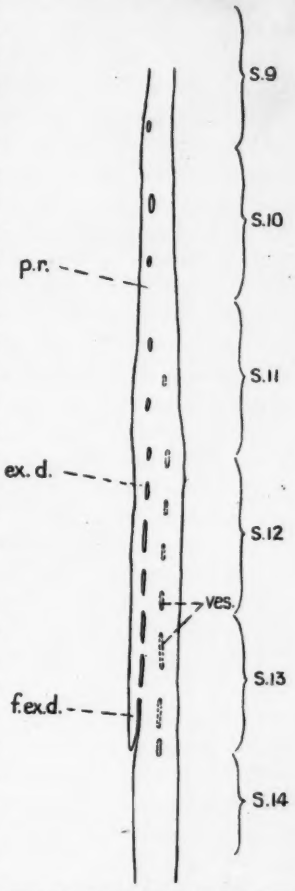
The coelomic chambers, so well developed in the last stage, cannot be recognised anteriorly, but from behind the 10th somite posteriorly there is present what appears as a thickened region of the somitic stalk, somewhat circular in cross section, lying immediately ventro-laterally to the pronephric ridge (plate XXXVI, fig. 8, *th.*). It has a solid connection with the coelomic epithelium, and within it at intervals small central cavities, often very indistinct, may be observed. Opposite this connection a slight groove in the coelomic wall may sometimes be seen. After running for some distance behind the last somite the thickened portion of the stalk disappears, and from this region backwards to near the hinder end of the embryo, we find a series of small coelomic chambers, similar to those of the last stage, in process of separating off from the general body cavity. If we compare fig. 8 with fig. 6 *a* and *b* of the preceding stage, there seems great probability that this thickened region of the stalk represents the united coelomic chambers of the earlier embryo, which have become closed off from the coelom.

The first indication of the formation of the excretory duct occurs at this stage. On the right side opposite somite 10, the solid dorsal margin of the pronephric ridge is continued backwards for ·03 mm. as a free cellular cord lying close to the ectoderm, the tip of which, only a few cells in thickness, unites once more with the ridge near the end of the somite. Small portions are again separated off from the dorsal margin of the ridge for ·01 or ·02 mm. opposite somites 11 and 12, and at this level they appear to be simply split off at intervals from the ridge, remaining connected with the latter at the intervening points. Whether the condition opposite somite 10, where the distal end of the free portion is distinctly tapering, represents a definite segmental outgrowth, is a question which must be left undetermined until more embryos of exactly this stage are available. In the next stage, an embryo of 16 somites, the dorsal margin of the ridge from near the anterior end of the 13th somite continues posteriorly quite free from the intermediate cell mass as far as the hinder region of the 15th somite. In one embryo of this age, however, its free tip terminates at the level of the anterior end of the 14th somite on the left side. The free portion forms a thin strip of cells, often distinctly tubular, and elongated in a dorso-lateral direction above the somitic stalk.

17 *somites.* The hinder end of each somite is united with the intermediate cell mass, except in the case of the first somite, which is smaller and quite isolated. Opposite the posterior end of the 7th somite there is a slight out-

growth from the dorsal side of the somitic stalk, but this is quite divided off from the ridge behind.

As in the embryo with 14 somites the coelomic chambers have completely disappeared in front of the 11th somite, but from the hinder end of the latter backwards there is present a thickened region of the stalk as described in the last stage. The small central cavities within it have now become more distinct, so that the region from the 11th to the end of the 15th somite takes the form of definite vesicles, attached end to end by solid cellular connections (text-fig. 1, *ves.*). There are two or three vesicles opposite each somite, though they are less developed opposite somite 11; each has a well marked central cavity and is attached to the coelomic epithelium by a solid mass of cells, opposite which a narrow slit-like peritoneal funnel may be present (plate XXXVII, figs. 12 and 13). Behind the level of the 15th somite, the vesicles run back into a solid swollen region of the somitic stalk, and only at about the level at which the 21st somite will later develop do we find small coelomic chambers still being cut off from the general coelom.




TEXT-FIG. 1. Embryo with 17 somites. Diagram of the pronephric ridge (*p.r.*) and primordium of the excretory duct (*ex.d.*), which has split off at intervals from the dorsal side of the ridge. *f.ex.d.* = free distal end of duct. *S* 9, 10, ... = level of somite 9, 10, .... *ves.* = vesicles in the thickened region of the somitic stalk.

The pronephric ridge, from the 8th as far as the anterior portion of the 11th somite, is seen as in preceding stages in the form of a thickening of the intermediate cell mass, but from this level to the end of the 13th somite, where the coelomic chambers have completely closed in, and have become transformed into a longitudinal cord of vesicles, as above described, the ridge passes on to this cord, and appears as a thickening on its dorsal wall, and where vesicles are developed, on the dorsal wall of the latter. This condition is well seen in plate XXXVII, fig. 14, which represents a section through the region of the 12th somite in an older embryo of 19 somites.

The separation of the excretory duct now is more pronounced. At the anterior end of the 8th somite a few cells pass off from the dorsal wall of the thickened side of the stalk and disappear without again uniting with the latter, but posterior to this level

once opposite the end of the 9th somite, twice opposite the 10th (plate XXXVII, fig. 9, *ex.d.*), and three times opposite the 11th and 12th, alternating with the vesicles, the dorsal margin of the ridge becomes split off, anteriorly as a small, posteriorly as a larger mass of cells, elongated in the direction of the long axis of the somitic stalk, and wedged in between the ridge and the ectoderm (text-fig. 1, *ex.d.*). The cells are for the most part radially arranged surrounding either a definite or a latent lumen. Proceeding in the caudal direction, the duct is divided off for longer intervals, so that opposite the 12th somite it is free throughout the greater part of the somite, union only occurring in odd sections. It is, however, very difficult to determine exactly when the duct is completely free, as a dividing line is often not easy to see. The duct is last connected with the ridge at the posterior end of the 13th somite where it terminates on the left, but on the right side it continues back near to the end of the 14th somite as a few cells almost embedded in the ectoderm, the latter at this point being very thin. An excretory tubule later arises opposite each vesicle where the connection with the duct is retained.

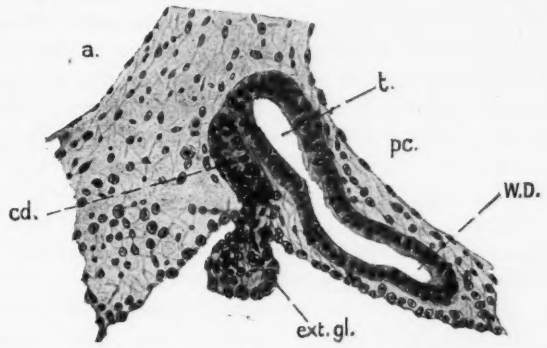
19 *somites*. The cranial end of the excretory primordium is now undergoing degeneration. A small solid outgrowth arises from the intermediate cell mass opposite the anterior portion of the 9th somite, but this is quite disconnected from the rest of the organ, the cranial end of which lies on a level with the hinder end of the 9th somite (plate XXXVIII, fig. 20, *p.r.*). The excretory duct is free behind the end of the 14th somite on the right, and behind the mid-region of this somite on the left side (plate XXXVIII, fig. 16), and running posteriorly, diminishes to a few cells which disappear behind the level of the 18th somite. It is noteworthy that posterior to the mid-region of the 14th somite on the left side a definite outgrowth was observed, extending out from the vesicle towards the duct, but failing to reach the latter. The region, therefore, which gives rise to the Wolffian duct, certainly does not extend posteriorly beyond the mid-region of the 14th somite, and very possibly not beyond the 13th somite.

The coelomic vesicles are well marked, three being present opposite the 11th, 12th, and 13th somites (plate XXXVII, fig. 14, plate XXXVIII, fig. 15, *ves.*), and two opposite each succeeding one up to the 16th, where they become less distinct, continuing back into a thickened area of the somitic stalk, which soon becomes solid, and which can be followed to the hinder end as a slightly swollen region of the mesoderm lying immediately adjacent to the coelom. Each vesicle is connected with the coelomic epithelium (plate XXXVIII, fig. 16, *con.*) by a solid mass of cells, opposite which a groove may be present.

In embryos with 20 somites, the vesicles opposite the 16th and 17th somites are already united with the Wolffian duct, the latter extending a short distance behind the 20th somite. Plate XXXVIII, fig. 17 shows the duct (*ex.d.*) near its posterior end in an embryo of 21 somites, lying in an indentation in the ectoderm. In some cases, as was observed in embryos of 22 to 23 somites, solid sprouts appear to grow out from the ventro-lateral wall of the duct towards

the vesicle, although more usually, the union between the two is effected by outgrowths from the dorso-lateral wall of the vesicle towards the duct.

*Later stages.* In succeeding stages the pronephric ridge disappears opposite the 8th somite, whilst in the region of the 9th, 10th, and cranial part of the 11th somites small tubular remnants are found, sometimes connected with the coelomic epithelium by a few cells. Behind this level definite mesonephric tubules are developed, although they are only small and vestigial opposite the 11th somite. In embryos of 27 somites for example, three or four are developing opposite the 11th somite, three opposite the 12th and 13th (plate XXXVIII, fig. 18), two or three opposite the 14th, and two opposite each succeeding somite; each is connected with the coelomic epithelium by a short solid band of cells, these bands being more distinct at some places than at others.




TEXT-FIG. 2. Embryo with 45 somites. Transverse section (composite) through the external glomerulus (*ext.gl.*) and first excretory tubule (*t*) in the region of the 9th somite and 6th spinal ganglion. Left side. *a* = aorta. *cd.* = degenerate cord of cells connecting the tubule with the glomerulus. *pc.* = posterior cardinal vein. *W.D.* = Wolffian duct.

(Sl. 5–5–4 to 7)

From the 18th somite backwards the vesicles are no longer united with the excretory duct; they gradually run into each other and their central cavities become reduced. The duct reaches the wall of the cloaca about this stage, and actually opens into the latter in embryos with 36 to 37 somites.

The mesonephric tubules are formed in the typical manner. The vesicle becomes flattened and invaginated, and develops into the Malpighian body, whilst the connection between the latter and the Wolffian duct becomes elongated and coiled to form the tubule. Definite glomeruli first appear in embryos with 35 to 36 somites, from the region of the 12th somite posteriorly; small and very rudimentary glomeruli may develop, opposite the end of the 11th somite, but these always remain vestigial. Plate XXXVIII, fig. 19, shows a well marked glomerulus developing in the region of the 12th somite in the embryo with 35 to 36 somites. At this stage the first somite is very small but apparently has not yet disappeared.

The primordium of the ureter first appears in an embryo of 38 to 39 somites as a slight dilatation on the dorsal side of the excretory duct, some distance behind the last tubule. At this stage, excluding about five tubular remnants at the anterior end, there are altogether 43 tubules on the left side, the last four not yet united with the duct. In an embryo with 50 to 51 somites, where the distal end of the ureter is expanding into the thick walled pelvis, surrounded by a dense layer of mesenchyme, about 50 tubules were counted; of these, one or two at the cranial end possessed only rudimentary glomeruli, whilst two or three glomeruli at the posterior end were very small and poorly developed. At one stage with 45 somites a very small but definite external glomerulus was present on a level with the first degenerate tubule of the left side, in the region of the 9th somite and the 6th spinal ganglion. A solid degenerate cord of cells connected the distal end of the tubule with the glomerulus (text-fig. 2, *ext.gl.*). In no other embryo was an external glomerulus observed.

In the oldest stage examined (about 55 somites) the Malpighian capsules were still connected with the coelomic epithelium either by strands of cells, or, more rarely, by a diffuse cellular mass.

## SUMMARY AND DISCUSSION

The cranial end of the excretory system in the cat is first developed in the form of a continuous ridge, the pronephric ridge, which arises as a thickening of the somatic layer of the intermediate cell mass or somitic stalk uniting the somite with the lateral plate. This thickening, which first appears in embryos with 8 to 9 somites, begins in the region of the 7th somite and increases gradually in thickness from before backwards to the level of the 13th or 14th somite. During the same time as the formation of the ridge, in embryos with 9 to 17 somites, a series of coelomic chambers becomes cut off from the general body cavity. They are very poorly developed anteriorly, but from the 9th somite backwards to the region of the shortened primitive streak, they form a well marked series one behind the other, being most conspicuous in the embryo of 12 somites. I have suggested that these structures represent vestigial pronephric chambers. When best developed (plate XXXV, fig. 5), each forms a well defined chamber lying immediately ventro-laterally to the pronephric ridge and communicating with the general body cavity by a narrow passage, the peritoneal funnel. In older embryos the coelomic chambers disappear completely in front of the 10th somite, probably becoming once more a part of the general coelom, but from this level down to the posterior end, they appear to become closed off from the coelom, and come to form a longitudinal cord of tissue, roughly circular in cross section, the entire cord being connected throughout its length with the coelomic epithelium by a short solid band of cells, representing the united and now closed peritoneal funnels. The cavities of the chambers become very much reduced in the anterior

portion from the 11th to the 14th somites but apparently never quite disappear, but behind this level they become completely obliterated. Very soon, however, cavities again appear, and the whole structure becomes divided up into a series of vesicles, three opposite each of the somites from the 11th to the 14th inclusive and two opposite each succeeding somite as far as the latter are developed, each vesicle being united with the coelomic epithelium by a solid column of cells, opposite which vestiges of a funnel may be present as a groove running inwards from the coelom.

In the region in front of the 11th somite the pronephric ridge has the form of a thickening of the dorsal wall of the somitic stalk, but from the hinder part of the 11th to the 13th or 14th somite, it appears as a thickening on the dorsal side of the longitudinal cord of tissue formed by the closed coelomic chambers, and therefore, at the points where vesicles develop, as a swelling on the wall of each vesicle.

From the pronephric ridge the excretory duct takes its origin. The ridge may be represented by a very slight swelling of the somatic wall of the stalk, consisting of a few cells, opposite the 6th somite, whilst opposite the 7th, it is very small and never contributes towards the formation of the excretory duct, nor are any tubules developed in this region. The rudiment opposite the 8th somite is more definite and may possibly take a small part in the composition of the duct. From this level posteriorly, a small portion becomes split off from the dorsal margin of the ridge at regular intervals, the amount separated off increasing in size from before backwards. The points at which connection is retained later become luminated and constitute the excretory tubules; from the region of the 11th to the 13th somites the tubules develop at the level of the vesicles, the splitting off occurring between the vesicles. Thus the region from the 8th or 9th to the 13th somites gives rise to the Wolffian duct, its main seat of origin being opposite the 11th, 12th, and 13th somites. Behind the 13th somite the duct grows back independently, and its union with the vesicles is a secondary one, occurring either as a solid outgrowth from the dorso-lateral wall of the vesicle towards the duct, or apparently sometimes as an outgrowth of the ventro-lateral wall of the duct towards the vesicle. It must be noted, however, that opposite the 14th somite a vesicle may be found to be united with the duct before the latter has begun to grow freely backwards, as in one embryo of 19 somites, so that the region from which the duct arises may extend as far as the 14th somite, and possibly varies in different embryos. In any case, at this level and also opposite somite 15, the union of the vesicles with the duct occurs very early; moreover, as will be seen from the subsequent discussion, the exact point from which the duct begins its independent growth is probably not of great morphological importance.

Unfortunately, the exact mode of origin of the anterior portion of the duct was not determined with certainty. In one embryo, that of 14 somites, a definite but very short outgrowth from the ridge is present at the level of the 10th somite; this extends dorsally and posteriorly, its hinder tapering end,

which consists of only two cells, uniting once more with the ridge. Posterior to this level, however, the duct appears simply to become split off from the ridge between the points at which tubules arise, and all signs of metamerism are absent from the first. Whether the condition opposite somite 10 is the normal one, and whether it represents a segmental outgrowth, it was not possible to decide without more embryos of this age. Definite segmental outgrowths, which unite to form the pronephric duct, have been described in the rabbit and mole by Kerens ('07) and at the cranial end in man by Felix ('12). They may possibly occur in the cat opposite the 8th and 9th somites as well as the 10th, but in this mammal the anterior end of the organ is very degenerate, and if a stage of definite segmental outgrowths is present, it is passed through with great rapidity, and could only be observed by the careful examination of many embryos of the same age.

The excretory duct when first formed is solid or possesses a latent lumen, and appears as a mass of cells lying dorsally to the pronephric ridge and just above the vesicles posteriorly to the ridge. Its posterior free tip consists of a fine cellular strand almost embedded in the ectoderm and sometimes almost indistinguishable from it. There is, however, no definite evidence that the ectoderm takes a part in the formation of the duct. Soon a distinct cavity appears within it, and it reaches the ventro-lateral wall of the cloaca in embryos with 27 to 29 somites, actually opening into the latter in stages with 36 to 37 somites.

The anterior end of the excretory organ in the cat is obviously undergoing atrophy. Opposite the 6th and 7th somites degeneration is almost complete, and neither in this region nor opposite somite 8 are any tubules developed. Isolated tubular remnants are present opposite the 9th somite, and posterior to this level they gradually become larger and more definite. They are still rudimentary and few in number opposite the 10th and beginning of the 11th somite, but towards the hinder region of the latter they increase in size and the first internal glomeruli are apparent, although here the latter are always very small and quite vestigial, the anterior end of the functional mesonephros lying in the region of the 12th somite.

The pronephric region in both reptiles and mammals is usually regarded as that region from which the excretory or Wolffian duct arises. That this distinction has no value is shown by Brauer in the Gymnophionan Hypogeophis. Here the pronephros is probably as well developed as in any other vertebrate, except perhaps the Myxinoids, and stretches from the 4th to the 15th segments; twelve pronephric canals are laid down but only the first three of these form the pronephric duct. The level at which the excretory duct becomes independent does not therefore necessarily mark the hinder limit of the pronephros. According to Kerens ('07), the duct takes its origin in the mole from three tubules arising opposite the 8th, 9th, and 10th somites, whilst in the rabbit an extra one is developed opposite the 7th somite. These tubules, which are thus strictly segmental, are all small and atrophy early. Posteriorly to the

10th somite the last tubule passes back into a cellular cord which becomes entirely separated from the lateral plate.

In the marmot as described by Janosik ('04), the dorsal portions of the "middle plate," connecting the somite with the lateral plate, from the distal end of the 6th to the 12th somites, give rise to a cell mass which eventually forms a cell strand, the latter growing distally as the Wolffian duct. The strand remains connected with the coelomic epithelium at intervals by rudimentary canals, six or seven being present. From the level of the 13th somite to the 15th or 16th, the duct is split off as a whole from the dorsal side of the middle plate, and posterior to this region it grows back independently. The cranial portion, as far as the level of the 12th somite, is regarded as homologous with the pronephros, and that between the 12th and 15th or 16th somite is considered as a region of transition between pro- and mesonephros. Here, and posteriorly to the hinder end of the mesonephros, the middle part separates off both from the somite and the coelomic epithelium, forming a cellular cord, which later divides into a species of dysmetameric vesicles. This process strikingly recalls the conditions in the cat. It is worthy of note that the primordium of the mesonephric canals, both in the marmot and the cat, is regarded as a portion cut off from the coelomic epithelium.

In an embryo of the bat, *Rhinolophus hipposideros*, van der Stricht ('13) has described two pronephric vestiges between the 7th and 8th somites, and one between the 9th and 10th on the left side, whilst on the right one is found opposite the 7th somite and two opposite the 8th and 9th.

The pronephros in man, as observed by Felix ('12), extends from the 7th to the 14th segments. Only the three anterior primordia are completely separated from each other and show some metamerism, whilst the hinder tubules are not segmental, altogether six being present opposite the 10th, 11th, and 12th segments. Whether this dysmetamerism is primary or not was not determined owing to want of sufficient material.

In Echidna (Keibel ('03)) vestiges of eight primordia have been observed in the region of the 4th, 5th, and 6th spinal ganglia, behind which typical mesonephric tubules begin, the first glomeruli appearing between the 7th and 8th spinal ganglia, that is presumably between the 10th and 11th somites, at a level only slightly in front of the anterior glomeruli in the cat.

In the marsupial Trichosurus vulpecula (Buchanan and Fraser ('18)) there are a large number (about 14 to 16) of degenerating excretory tubules, beginning opposite the 4th spinal ganglion and extending as far as the 8th, where rudimentary internal glomeruli are developed. As the necessary early stages were missing it was not possible to ascertain how many of these take part in the formation of the excretory duct. In an embryo of Perameles, however, with 15 to 16 somites, the excretory tubules appear to be primarily connected with the duct as far back as the 13th somite, and it is quite possible that this condition also exists in Trichosurus, for it is evident, from our observations on the cat, that the presence of internal glomeruli does not mark the boundary

between so-called pro- and mesonephric tubules, as was supposed in the earlier paper on Trichosurus ('18). In Trichosurus, as in the cat, there was absolutely no evidence of the two kinds of tubules occurring in the same segment.

The mode of origin of the mesonephric tubules in the cat follows that described in other forms. The dorsal wall of each vesicle becomes flattened and then invaginated to form the Malpighian capsule, on the dorsal side of which the glomerulus arises. The solid connection between the vesicle and the Wolffian duct soon becomes tubular and coiled, and eventually develops into the secretory and excretory parts of the organ. The vesicles extending from the level of the hinder end of the 11th to the 13th somites, from which the duct takes its origin, give rise to tubules which are serially homologous with those behind this region; all are typical mesonephric tubules. That being so, the distinction in the cat between pronephric and mesonephric regions is purely arbitrary, for no definite line can be drawn between the two areas. The whole excretory organ must be looked upon as one continuous organ, the anterior portion of which shows progressive deterioration from behind forwards.

The view that pro- and mesonephros are different parts of the same organ was first put forward by Balfour and Sedgwick ('79), was later supported by Renson ('83) and Weldon ('83), and has since been upheld by several recent investigators [Wiedersheim ('90) in reptiles, Field ('91) in Amphibia, Price ('97 and '04) in Myxinoids, Brauer ('02) in the Gymnophiona, Kerens ('07) in Reptilia, Aves and Mammalia, Burland ('13) in Chelonia, and Borcea ('05) in Elasmobranchii]. More recently Graham Kerr ('19) has supported the same theory in his text book on the embryology of Fishes and Sauropsida. Many observers [Rückert ('88), van Wijhe ('89) and Rabl ('96) in Selachii, Semon ('92) in Ichthyophis, Hoffmann ('89) in Lacerta, Felix ('91) in the chick, Maas ('97) in Myxine, Wheeler ('99) and Hatta ('00) in Petromyzon, Gregory ('09) in the Turtle] regard the pronephros as having once extended all down the body, but as having later undergone atrophy, being replaced, except in the cranial region, by another series of tubules forming the mesonephros. These authors contend that both pro- and mesonephric canals may develop in the same segments, the mesonephric primordia arising from a more dorsal part of the somitic stalk than the pronephric. It must be said, however, that the figures given to illustrate so-called mesonephric primordia in the pronephric region are quite unconvincing.

It seems very probable, as Brauer ('02) suggests, that the canal-like connection between the somite and the nephrotome, seen in the last stage of separation between the two, has in some instances, been mistaken for a mesonephric canal. In the cat, the portion of the somitic stalk connecting the hinder end of the somite with the pronephric ridge often contains a distinct central cavity, forming, in cross section, a vesicular region of the stalk. This is especially well marked in embryos with 19 somites (plate XXXVIII, fig. 20, *s.q.*), but later completely disappears. In the cat, however, such structures have

no connection whatever with the mesonephric vesicles, which arise laterally to the pronephric ridge.

Borcea ('05), in his studies on Elasmobranchii, also considers that the mesonephric canals arise from a more dorsal part of the nephrotome than the pronephric, but that the limits between the two cannot be definitely determined, and he holds at the same time that pro- and mesonephros are parts of one organ, at first similar, but later undergoing physiological differentiation in two directions. This difference in function has led to a difference in development (Borcea, p. 340).

That the external glomeruli of the pronephros are homodynamous with the internal glomeruli of the mesonephros, the one gradually passing into the other, has been pointed out by Sedgwick ('81), also by Renson ('83) and Mihalkovics ('85), although the latter worker did not consider the homology between the two excretory organs a complete one. Many of the later workers also look upon the Malpighian capsules simply as pronephric chambers or nephrotomes, which have become completely closed off from the body cavity, the external glomerulus thus becoming internal. This view is upheld by Wiedersheim ('90) and Burland ('13) in Reptilia, Field ('91) in Amphibia, Price ('97) in Myxinoidei, Brauer ('02) in Hypogeophis, and Borcea ('05) in Elasmobranchii. The similarity of the two structures is illustrated in Lepidosteus (Balfour and Parker ('82) and Beard ('94)) where the glomerulus of the pronephros lies in a chamber which is cut off from the body cavity, and which is identical with a Malpighian capsule. According to Price, who has investigated Bdellostoma, the homology between the two is a very complete one. In the Mammalia this homology has not been demonstrated, the rudimentary state of the anterior end of the excretory organ and the absence of external glomeruli, except in a very degenerate condition, making a comparison between the latter and the internal glomeruli of the mesonephros almost impossible. In early embryos of the cat there is a series of coelomic chambers extending from the 6th somite to the hinder end of the body. Such structures do not appear to have been previously described in a mammal; they are, however, quite definite in the cat, and it has been suggested that they are equivalent to vestigial pronephric chambers. They are especially well developed in the embryo with 12 somites, but they very soon undergo a change, and from the region of the 11th somite backwards, close off from the coelom and come to form an almost solid cord (corresponding with a nephrogenic cord), attached throughout its length to the coelomic epithelium. This cord later divides up into a series of vesicles, the central cavity in each of which, behind the level of the 13th somite, arises secondarily. Each vesicle remains united with the coelomic epithelium by a solid mass of cells. Though it is difficult to demonstrate conclusively that the longitudinal cord of tissue, in which the vesicles arise, is actually derived from the pronephric chambers, this interpretation seems to be the correct one. If so, then the pronephric chambers are homologous with the Malpighian capsules.

The connections of the vesicles with the coelomic epithelium, representing the closed peritoneal funnels, persist for a considerable period. When the Malpighian body is developed, its ventral wall is seen to be connected with the coelomic epithelium either by a more or less definite cord of cells, or by a diffuse mass of mesenchyme, similar to that described in the marsupial Perameles (Fraser, '19). In the cat, these atrophied funnels are still present in an embryo with about 55 somites, but as I have not yet studied older stages, it is not possible to say whether or not they are transformed directly into the rete tubules as in the case of Perameles. The development of the vasa efferentia has, however, been studied by Sainmont ('06). This author states that the rete first appears in embryos of 24 days, when it arises as outgrowths from the walls of the Malpighian capsules. It is not unusual for the peritoneal connection of the mesonephric tubules to be lost and regained, a secondary union arising as an outgrowth from Bowman's capsule towards the coelomic epithelium, and developing finally into a definite open peritoneal funnel. This condition is found, for example, in Hypogeophis (Brauer, '02) and also in Amphibia (Fürbringer '78). That great variation exists is evident from the divergence of opinion expressed by so many observers, not only in different vertebrates but in one and the same species, some attributing the origin of the rete to outgrowths of the Malpighian bodies, others to evaginations of the peritoneal epithelium, and yet others to a condensation of mesenchyme lying between the peritoneum and Bowman's capsules. Many workers, again, experience great difficulty in distinguishing the exact origin of the cells from which the rete is derived.

In conclusion, it may be said that the anterior region of the excretory system in the cat is as well developed as in other mammals, with the probable exception of the Marsupialia and the Monotremata. The number of rudimentary tubules, although slightly in excess of man, is apparently less than in marsupials. The cranial end is undergoing atrophy as in all mammals, and whilst the incompletely formed tubules in front of the 11th somite may possibly have a segmental origin, behind this level all signs of metamerism have disappeared. Vestigial external glomeruli may develop in later stages (e.g. 45 somites) but only rarely; such structures have been described in man, and in the marsupial Trichosurus, but in the rabbit, mole, and marmot they appear to be completely absent. The whole excretory system is composed of one continuous series of tubules, the structure of which increases in complexity in an antero-posterior direction, there being no clear distinction between the anterior tubules ordinarily regarded as forming the pronephros, and the posterior tubules of the mesonephros.

## CONCLUSIONS

The embryonic excretory system in the cat is one continuous organ, the degenerate anterior end passing posteriorly into the fully developed mesonephros.

In early stages an intermediate cell mass or somitic stalk connects the mesoblastic somite with the lateral plate.

A pronephric ridge is developed as a thickening of the somatic wall of the intermediate cell mass. This ridge extends from the level of the 6th to the 13th or 14th somite increasing in thickness from before backwards. The hinder portion, from the region of the 9th somite posteriorly gives origin to the excretory or Wolffian duct.

During the formation of the pronephric ridge and immediately laterally to it, a series of coelomic chambers become cut off from the general body cavity communicating with the latter by a narrow passage. These extend from about the level of the 6th somite almost to the posterior end of the embryo. It is suggested that they represent vestigial pronephric chambers, each with a peritoneal funnel.

The chambers in front of the 11th somite soon disappear, but behind this region it appears as if they become completely closed off from the body cavity so as to form an almost solid longitudinal cord of tissue, attached throughout its length to the coelomic epithelium by a solid band of cells, representing the closed peritoneal funnels.

Later this cord becomes divided into a series of vesicles each united to the coelomic epithelium by a cord of cells. In the region from about the 11th to the end of the 13th somite the cavities of the coelomic chambers become reduced but nevertheless persist, but posteriorly the vesicles arise secondarily within the cord. There are three vesicles opposite the 11th to the 14th somites, and two opposite each somite posteriorly.

The greater part of the Wolffian duct arises in the region of the 11th to the 13th somites. It becomes split off from the dorsal margin of the ridge between the vesicles, connection being retained opposite the latter where tubules later arise. In front of the 11th somite definite segmental outgrowths may possibly occur from the ridge, the distal ends of which unite to form the anterior end of the excretory duct.

Behind the level of the 13th or 14th somite the duct grows back independently, its free tip lying in an indentation of the ectoderm. There is no direct evidence that the ectoderm takes a part in its formation.

The Wolffian duct reaches the wall of the cloaca in embryos with 29 somites and opens into the latter in embryos with 36 to 37 somites.

From the 11th to the 13th somites the connection of the vesicles with the Wolffian duct is thus primary, behind this level the union is a secondary one.

Each vesicle develops into the Malpighian body of a mesonephric tubule and the connection between the vesicle and the duct becomes the excretory tubule.

Definite mesonephric tubules are present from the level of the hinder end of the 11th somite posteriorly, though the glomeruli at the extreme anterior end are quite rudimentary. In front of this level only vestigial tubules are developed.

An external glomerulus was observed in only one embryo with 45 somites in the region of the 9th somite and the 6th spinal ganglion.

## LIST OF REFERENCES


('75) Balfour, F. M. "On the Origin and History of the Urinogenital Organs of Vertebrates." *Journ. Anat. and Phys.* vol. x. 1875.

('85) —— *A Treatise on Comparative Embryology.* London, 1885.

('79) Balfour, F. M. and Sedgwick, A. "On the Existence of a Head-Kidney in the Embryo Chick and on certain points in the Development of the Müllerian Duct." *Quart. Journ. Micr. Sc.* vol. xix. 1879.

('82) Balfour, F. M. and Parker, W. N. "On the Structure and Development of Lepidosteus." *Phil. Trans. Roy. Soc.* 1882.

('94) Beard, J. "The Pronephros of *Lepidosteus osseus.*" *Anat. Anz.* No. 6, 1894.

('05) Borcea, I. *Recherches sur le Système Uro-génital des Elasmobranches.* Paris, 1905 and *Arch. de Zool. Expér. et Gén.* T. iv. 1905–06.

('02) Brauer, A. "Beiträge zur Kenntnis der Entwicklung und Anatomie der Gymnophionen. III. Die Entwicklung der Excretionsorgane." *Zool. Jahrb.* Bd xvii. 1902.

('18) Buchanan, G. and Fraser, E. A. "The Development of the Urogenital System in the Marsupialia, with special reference to *Trichosurus vulpecula.*" Part I, *Journ. of Anat.* vol. liii. 1918.

('13) Burland, T. H. "The Pronephros of *Chrysemys marginata.*" *Zool. Jahrb.* Bd. xxxvi. 1913.

('91) Felix, W. "Die erste Anlage des Excretions-systems des Hühnchens." Festschr. *Nägeli u. Kolliker,* Zurich, 1891.

('12) —— "The Development of the Urogenital Organs." *Manual of Human Embryology,* Keibel and Mall, vol. ii. 1912.

('91) Field, H. H. "The Development of the Pronephros and Segmental Duct in Amphibia." *Bull. Mus. Comp. Zool.* vol. xxi. 1891.

('19) Fraser, E. A. "The Development of the Urogenital System in the Marsupialia, with special reference to *Trichosurus vulpecula.*" Part II, *Journ of Anat.* vol. liii. 1919.

('78) Fürbringer, M. "Zur vergleichenden Anatomie und Entwickelungsgeschichte der Exkretionsorgane der Vertebraten." *Morph. Jahrb.* Bd. iv. 1878.

('09) Gregory, E. R. "Observations on the Development of the Excretory System in Turtles." *Morph. Jahrb.* Bd xiii. 1909.

('00) Hatta, S. "Contributions to the Morphology of Cyclostomata. II. The Development of Pronephros and Segmental Duct in Petromyzon." *Journ. Coll. Sc.* Tokyo, vol. xiii. 1900–01.

('89) Hoffmann, C. R. "Zur Entwicklungsgeschichte der Urogenitalorgane bei den Reptilien." *Zeitschr. f. wiss. Zool.* Bd xlviii. 1889.

('85) Janosik, J. "Histologisch-embryologische Untersuchungen über das Urogenitalsystem." *Sitzber. Akad. Wien.* 3 *Abth.* Bd xci. 1885.

('04) —— "Über die Entwickelung der Vorniere und des Vornieren-ganges bei Säugern." *Extr. Bull. Ac. Soc.* Prague, 1904. *Arch. f. mikr. Anat.* Bd lxiv. 1904.

('03) Keibel, F. "Zur Entwickelungsgeschichte des Urogenitalapparates von *Echidna aculeata* var. *typica.*" *Semon. Zool. Forsch. in Australien u. den malayischen Archipel.* Lief. xxii. 1903.

('07) Kerens, B. "Recherches sur les premières phases du développement de l'Appareil excréteur des Amniotes." *Arch. de Biol.* T. xxii. 1906–07.

('19) Kerr, J. Graham. *Textbook of Embryology,* vol. ii. Vertebrata. 1919.

('97) Maas, O. "Ueber Entwicklungsstadien der Vorniere und Urniere bei Myxine." *Zool Jahrb.* Bd x. 1897.

('88) Martin, E. "Ueber die Anlage der Urniere beim Kaninchen." *Arch. f. Anat. u. Phys.* 1888.

('85) Mihalkovics, G. von. "Untersuchungen über die Entwickelung des Harn und Geschlechtsapparates der Amnioten." *Internat. Journ. of Anat. and Hist.* vol. ii. 1885.

('97) Price, G. C. "Development of the Excretory Organs of a Myxinoid, *Bdellostoma stouti* Lockington." *Zool. Jahrb.* Bd x. 1897.

('04) —— "Further study of the Development of the Excretory System in *Bdellostoma stouti.*" *Amer. Journ. of Anat.* vol. iv. 1904.

('96) Rabl, C. "Über die Entwicklung des Urogenitalsystems der Selachier." *Morph. Jahrb.* Bd. xxiv. 1896.

('83) RENSON, G. "Recherches sur le rein cephalique et le corps de Wolff chez les Oiseaux et les Mammifères" (Extrait). *Arch. f. mikro. Anat.* Bd XXII. 1883.

('88) RÜCKERT, J. "Ueber die Entstehung der Excretionsorgane bei Selachiern." *Arch. f. Anat. u. Phys.* 1888.

('91) —— "Entwickelung der Excretionsorgane." *Anat. Hefte.* Abth. 2, Bd I. 1891.

('06) SAINMONT, G. "Recherches relative a l'organogenèse du testicule et de l'ovaire chez le chat." *Arch. de Biol.* T. XXII. 1906–07.

('81) SEDGWICK, A. "On the early development of the anterior part of the Wolffian Duct and Body in the Chick, together with some remarks on the Excretory System of the Vertebrata." *Quart. Journ. Micr. Sc.* vol. XXI. 1881.

('92) SEMON, R. "Studien über den Bauplan des Urogenitalsystems der Wirbeltiere." *Jen. Zeitschr. f. Naturwiss.* Bd. XXVI. 1892.

('13) STRICHT, O. VAN DER. "Le Mésonephros chez la Chauve-souris." *Compt. Rend. de l'Assoc. des Anat.* 1913.

('99) SWAEN, A. et BRACHET, A. "Etude sur les premières phases du développement des organes dérivés du mésoblaste chez le poissons téléostéens." *Arch. de Biol.* T. XVI. 1899.

('83). WELDON, W. F. R. "Note on the Early Development of *Lacerta muralis*." *Quart Journ. Micr. Sc.* vol. XXIII. 1883.

('99) WHEELER, W. M. "Development of the Urinogenital Organs of the Lamprey." *Zool. Jahrb.* Bd XIII. 1899.

('90) WIEDERSHEIM, R. "Über die Entwicklung des Urogenitalapparates bei Krocodilen und Schildkröten." *Anat. Anz.* Bd V. 1890.

('89) WIJHE, J. W. VAN. "Ueber die Mesoderm-segmente des Rumpfes und die Entwicklung des Excretionssystems bei Selachiern." *Arch. f. mikr. Anat.* Bd XXXIII. 1889.

## REFERENCE LETTERS

*a* = dorsal aorta; *b.c.* = body cavity; *c.ch.* = coelomic chamber; *ect.* = ectoderm; *ent.* = entoderm; *ex.d.* = excretory duct; *m.p.* = medullary plate; *n.* = notochord; *n.t.* = neural tube; *p.f.* = peritoneal funnel; *p.r.* = pronephric ridge; *S*1, 2, ... = somite 1, 2, ... ; *smpl.* = somatopleure; *spl.* = splanchnopleure; *ves.* = coelomic vesicle.

## DESCRIPTION OF PLATES

The figures are reproduced at a magnification of 200 diam.

Fig. 1 *a*. Embryo with 9 to 10 somites. Transverse section at the level of the 8th somite, showing the somitic stalk or intermediate cell mass at the point where it is isolated from the somite. Left side. (Sl. 2–6–14.)

Fig. 1 *b*. Embryo with 9 to 10 somites. ·01 mm. behind *a*, showing the thickening of the dorsal wall (*p.r.*) of the somitic stalk. (Sl. 2–6–15.)

Fig. 2. Embryo with 9 to 10 somites. Transverse section at the level of the 9th somite on the left side, showing the coelomic chamber (*c.ch.*) and thickening of the somitic stalk. The latter in this section is not united with the somite. (Sl. 2–7–8.)

Fig. 3. Embryo with 9 to 10 somites. Transverse section at the level of the 10th somite, showing the thickening of the somitic stalk (*p.r.*). (Sl. 2–7–16.)

Fig. 4. Embryo with 12 somites. Transverse section through the hinder end of the 8th somite, showing the mid-region of the somitic stalk, which is attached to the lateral plate and disconnected from the somite. Left side. (Sl. 2–1–14.)

Fig. 5. Embryo with 12 somites. Transverse section at the level of the 10th somite, showing the well developed coelomic chamber (*c.ch.*) and the pronephric ridge (*p.r.*). The peritoneal funnel does not appear in this section. Left side. (Sl. 2–3–11.)

Fig. 6 *a* and *b*. Embryo with 12 somites. Two consecutive transverse sections at the level of the 11th somite, showing the pronephric ridge (*p.r.*) and the coelomic chamber (*c.ch.*) with its peritoneal funnel (*p.f.*). Left side. (Sl. 2–4–10 and 11.)

Fig. 7 *a* and *b*. Embryo with 12 somites. Two consecutive transverse sections in the region of the shortened primitive streak, showing a coelomic chamber (*c.ch.*) with its peritoneal funnel (*p.f.*). Left side. (Sl. 3–3–10 and 11.)

Fig. 8. Embryo with 14 somites. Transverse section at the level of the 13th somite, showing the pronephric ridge (*p.r.*) and the thickened region of the somitic stalk (*th.*) derived in all probability from a closed coelomic chamber. Right side. (Sl. 3–4–7.)

Fig. 9. Embryo with 17 somites. Transverse section at the level of the 10th somite, showing the separation of the excretory duct (*ex.d.*) from the dorsal margin of the pronephric ridge (*p.r.*). Left side. (Sl. 4–3–8.)

Fig. 10. Embryo with 17 somites. Transverse section showing the pronephric ridge (*p.r.*) at the level of the 10th somite. Right side. (Sl. 4–3–9.)

Fig. 11. Embryo with 17 somites. Transverse section showing the pronephric ridge at the level of the 11th somite. Right side. (Sl. 4–5–7.)

Fig. 12. Embryo with 17 somites. Transverse section at the level of the anterior end of the 13th somite, through the anterior wall of a vesicle (*ves.*), and showing the last vestige of the peri toneal funnel (*p.f.*). The excretory duct (*ex.d.*) lies free above the vesicle. Right side. (Sl. 5–2–3.)

Fig. 13. Embryo with 17 somites. Transverse section, ·03 mm. posterior to fig. 12, showing the central cavity within the vesicle, and the free excretory duct (*ex.d.*) above the latter. (Sl. 5–2–6.)

Fig. 14. Embryo with 19 somites. Transverse section in the region of the 12th somite, showing the pronephric ridge (*p.r.*) forming a thickening of the dorsal wall of the vesicle (*ves.*). (Sl. 1–7–15.)

Fig. 15. Embryo with 19 somites. Transverse section at the level of the 13th somite, showing the free excretory duct lying immediately dorsally to a vesicle, and a short distance behind its last connection with the pronephric ridge. Left side. (Sl. 4–5–10.)

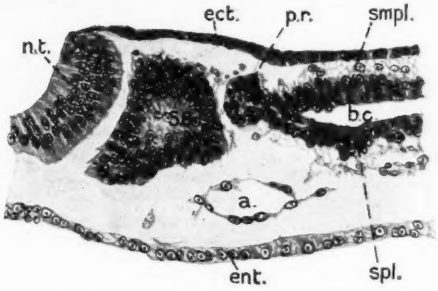
Fig. 16. Embryo with 19 somites. Transverse section between the 14th and 15th somites, showing the solid connection (*con.*) of a vesicle with the coelomic epithelium. The now luminated excretory duct is seen lying dorsally to the vesicle. Left side. (Sl. 1–9–6.)

Fig. 17. Embryo with 21 somites. Transverse section showing the excretory duct (*ex.d.*) near its hinder end lying in an indentation of the ectoderm. *s.mes.* = somitic mesoderm. (Sl. 7–4–5.)

Fig. 18. Embryo with 27 somites. Transverse section through a developing mesonephric tubule at the level of the 13th somite. Right side. *M.c.* = future Malpighian capsule. (Sl. 2–1–17.)

Fig. 19. Embryo with 35 to 36 somites. Transverse section at the level of the 12th somite and 9th spinal ganglion, showing an excretory tubule (*ex.t.*) with its developing glomerulus (*gl.*). Left side. (Sl. 3–4–5.)

Fig. 20. Embryo with 19 somites. Transverse section between the 9th and 10th somites, showing the vesicular region (*S.* 9) of the somitic stalk connecting the hinder end of the 9th somite with the pronephric ridge (*p.r.*). Right side. (Sl. 1–5–9.)

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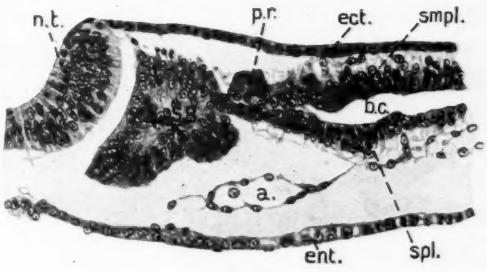


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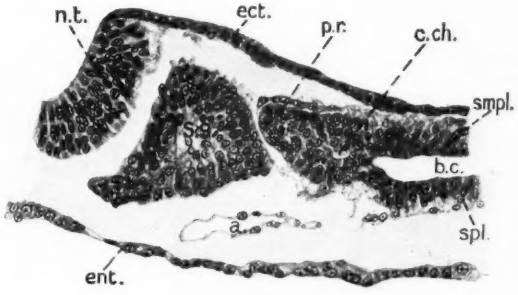


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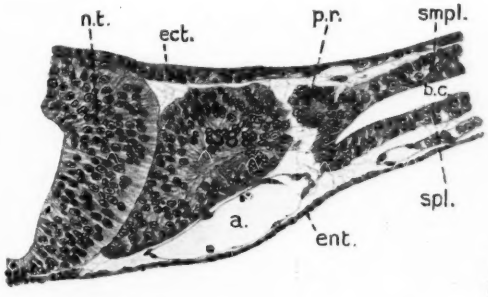


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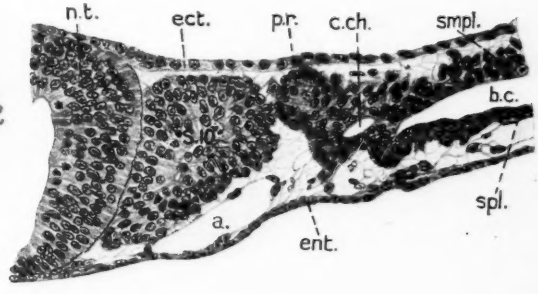


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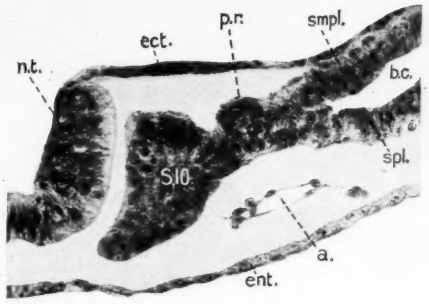


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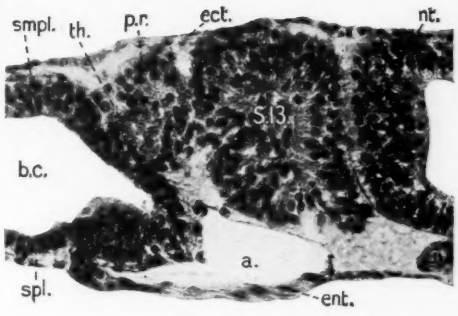


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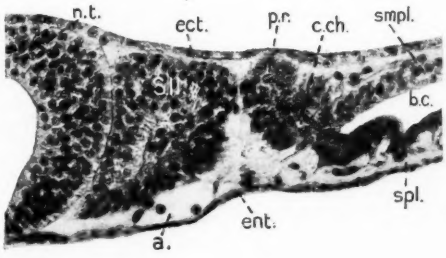


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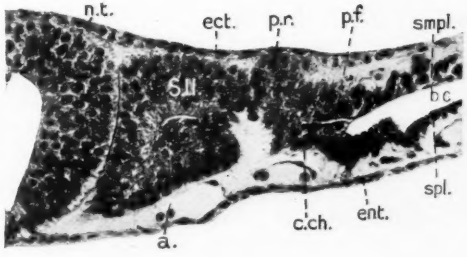


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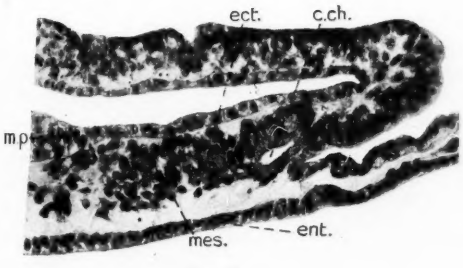


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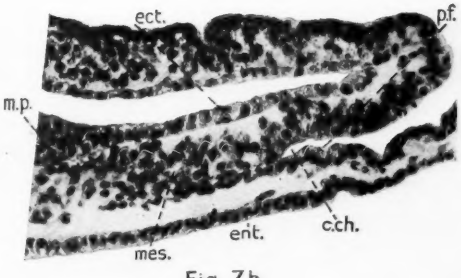


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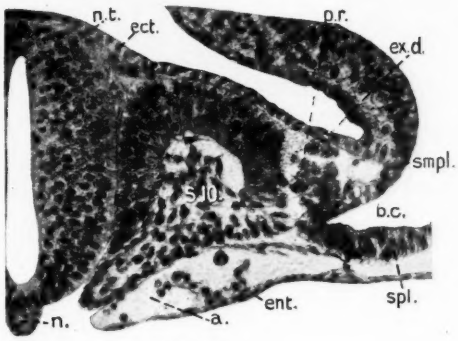


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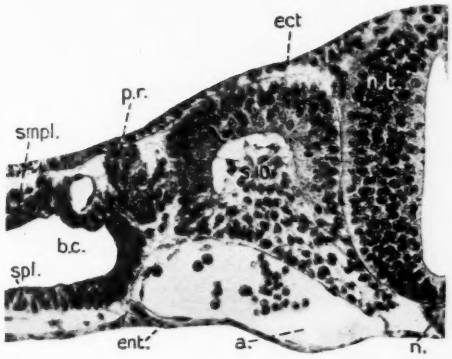


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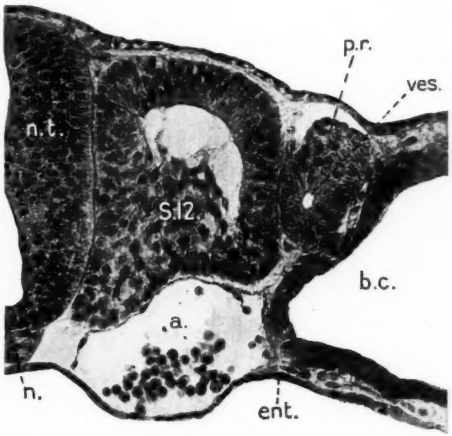


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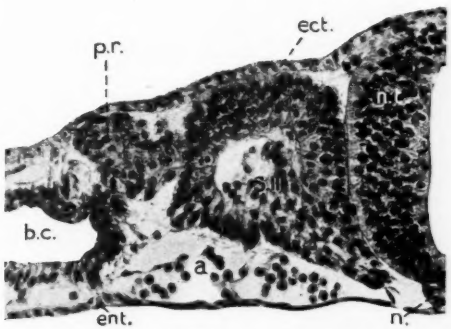


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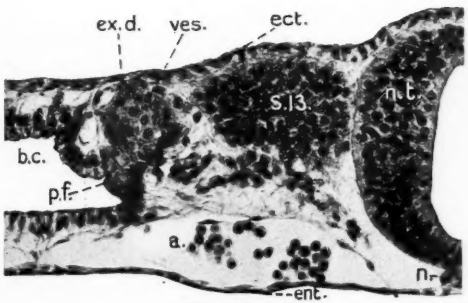


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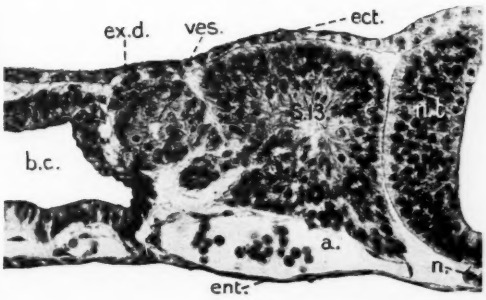



Fig. 13.

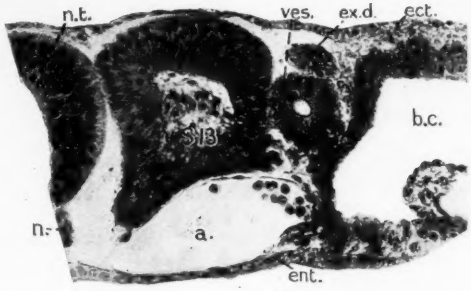



Fig. 15.

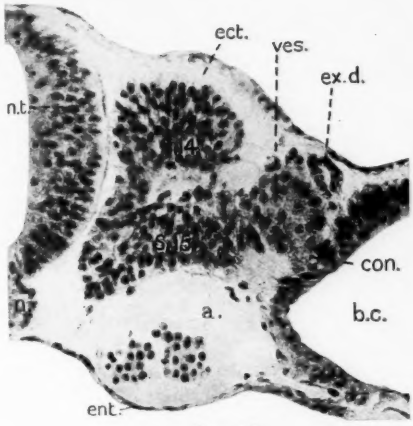



Fig. 16.

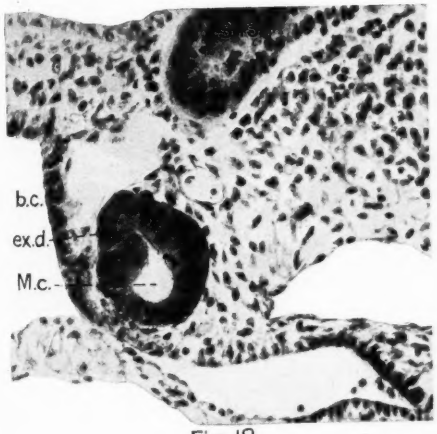



Fig. 18.

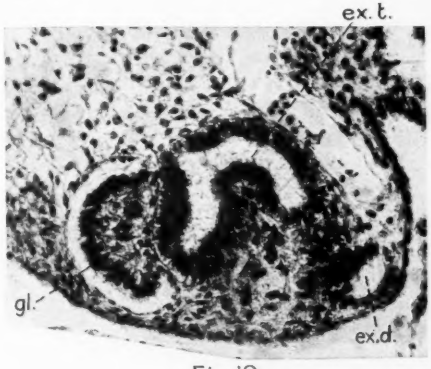



Fig. 19.

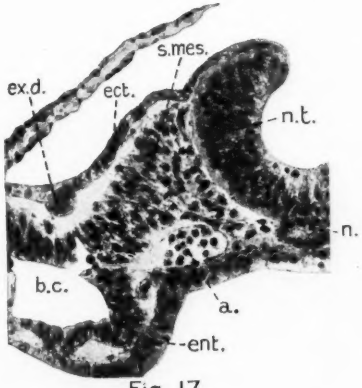



Fig. 17.

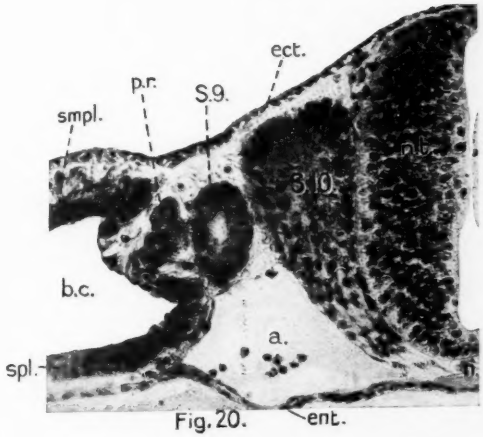



Fig. 20.

# ON CERTAIN ABSOLUTE AND RELATIVE MEASUREMENTS OF HUMAN VERTEBRAE

By EDGAR F. CYRIAX, M.D. (Edin.),
*London.*

Some years ago Anderson[1] and Dwight[2] made a series of measurements of certain diameters of human vertebrae, namely the anterior vertical, posterior vertical, transverse and antero-posterior of the body and the transverse of the whole bone. Their results agreed very closely in most cases. Neither of these authors however appear to have measured the antero-posterior diameter of the whole vertebra nor to have attempted to ascertain whether any constant ratios existed between the various measurements obtained. It seemed to me that such an investigation might prove of interest, partly from the purely anatomical and anthropological aspect, partly from the view of interpretation of skiagrams and correct estimation of spinal deformities, and possibly also from the medico-legal point of view.

I accordingly made a series of measurements of (as far as could be ascertained) normal human vertebrae taken from 36 articulated and disarticulated skeletons and spinal columns, 9 dry preparations of vertebral war injuries and about 600 loose vertebrae: in all 1482 bones were thus examined. The actual measurements taken were as follows:

(1) The mesial anterior vertical diameter of the body.

(2) The lateral diameter of the body. In the cervical region this was measured just above its lower margin, in the dorsal and lumbar at the middle of the body, thus obtaining its minimum lateral diameter.

(3) The maximum diameter of the whole vertebra, i.e. the spread of the transverse processes.

(4) The maximum antero-posterior diameter of the whole vertebra. This was measured from the centre of the lower margin of the body to the most distant point on the spinous process.

For the sake of brevity these diameters will be referred to as: body, A.V.D.; body, L.D.; T.D. and A-P.D.

From the measurements thus obtained, the following ratios were then calculated:

(*a*) Body A.V.D. to T.D.
(*b*) Body A.V.D. to A-P.D.
(*c*) Body L.D. to T.D.
(*d*) Body L.D. to A-P.D.
(*e*) T.D. to A-P.D.

[1] *Journ. of Anat. and Phys.* 1883, xvii. 341–344.
[2] Quoted Piersol, *Human Anatomy*, 1908, p. 122.

I found that although individual characteristics are quite constant, very great variations occurred in both measurements and ratios, specially the latter, 60 per cent. being quite common, and 100 per cent. being reached in a few cases. As examples I give the results obtained from the first six specimens examined in the following three vertebrae:

*Fifth cervical.*

| | mm. | mm. | mm. | mm. | mm. | mm. |
|---|---|---|---|---|---|---|
| (*a*) Body A.V.D. ... | 15 | 9 | 13 | 13 | 11 | 13 |
| (*b*) Body L.D. ... ... | 24·5 | 24 | 24 | 22 | 20 | 18·5 |
| (*c*) T.D. ... ... | 59 | 58 | 61·5 | 58·5 | 48 | 50·5 |
| (*d*) A-P.D. ... ... | 46·5 | 47 | 51 | 48·5 | 45·5 | 41·5 |
| | % | % | % | % | % | % |
| Ratio of (*a*) to (*c*) ... | 25 | 16 | 21 | 22 | 23 | 26 |
| „ (*a*) to (*d*) ... | 32 | 19 | 25 | 27 | 24 | 31 |
| „ (*b*) to (*c*) ... | 42 | 41 | 39 | 38 | 42 | 37 |
| „ (*b*) to (*d*) ... | 53 | 51 | 47 | 45 | 44 | 45 |
| „ (*c*) to (*d*) ... | 127 | 123 | 121 | 121 | 105 | 122 |

*Sixth dorsal.*

| | mm. | mm. | mm. | mm. | mm. | mm. |
|---|---|---|---|---|---|---|
| (*a*) Body A.V.D. ... | 19 | 19 | 19 | 21 | 20 | 21 |
| (*b*) Body L.D. ... ... | 23 | 23·5 | 27 | 30·5 | 31 | 29 |
| (*c*) T.D. ... ... | 54·5 | 54 | 63·5 | 68 | 67·5 | 68·5 |
| (*d*) A-P.D. ... ... | 59 | 62 | 70 | 77 | 72·5 | 75 |
| | % | % | % | % | % | % |
| Ratio of (*a*) to (*c*) ... | 35 | 35 | 30 | 31 | 30 | 31 |
| „ (*a*) to (*d*) ... | 32 | 31 | 27 | 27 | 28 | 28 |
| „ (*b*) to (*c*) ... | 42 | 44 | 42 | 45 | 46 | 42 |
| „ (*b*) to (*d*) ... | 39 | 38 | 39 | 40 | 43 | 39 |
| „ (*c*) to (*d*) ... | 91 | 87 | 91 | 88 | 93 | 91 |

*Third lumbar.*

| | mm. | mm. | mm. | mm. | mm. | mm. |
|---|---|---|---|---|---|---|
| (*a*) Body A.V.D. ... | 30 | 24 | 24 | 27 | 30 | 28 |
| (*b*) Body L.D. ... ... | 45 | 42·5 | 44 | 41 | 39 | 31·5 |
| (*c*) T.D. ... ... | 108 | 83 | 82 | 98 | 79 | 76·5 |
| (*d*) A-P.D. ... ... | 85 | 77 | 85 | 86·5 | 76 | 70·5 |
| | % | % | % | % | % | % |
| Ratio of (*a*) to (*c*) ... | 28 | 29 | 29 | 28 | 38 | 37 |
| „ (*a*) to (*d*) ... | 35 | 31 | 28 | 31 | 39 | 40 |
| „ (*b*) to (*c*) ... | 42 | 51 | 54 | 42 | 49 | 41 |
| „ (*b*) to (*d*) ... | 53 | 55 | 52 | 47 | 51 | 45 |
| „ (*c*) to (*d*) ... | 127 | 108 | 96 | 113 | 104 | 109 |

The summary of the measurements (calculated to the nearest whole number) and ratios are given below. I have not made separate summaries of male and female bones respectively because in all but a very few cases it was impossible to be certain that any given skeleton consisted entirely of the bones of purely one individual; moreover I was informed that the makers of articulated skeletons occasionally join male spinal columns to female pelves

### *Summary of diameters.*

| | No. of specimens examined | Body A.V.D. | | | Body L.D. | | | T.D. | | | A-P.D. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Average mm. | Min. | Max. | Average mm. | Min. | Max. | Average mm. | Min. | Max. | Average mm. | Min. | Max. |
| C 1 | 152 | — | — | — | — | — | — | 78·07 | 63 | 90 | 45·41 | 39 | 53 |
| C 2 | 157 | 39·22 | 30 | 49 | — | — | — | 54·49 | 44 | 65 | 50·59 | 43 | 58 |
| C 3 | 42 | 12·85 | 10 | 16 | 20·94 | 14 | 25 | 53·48 | 44 | 60 | 44·92 | 39 | 54 |
| C 4 | 37 | 12·55 | 7 | 15 | 21·30 | 17 | 25 | 55·07 | 47 | 61 | 45·07 | 39 | 54 |
| C 5 | 38 | 12·16 | 9 | 16 | 22·58 | 18 | 25 | 57·04 | 48 | 64 | 47·67 | 41 | 61 |
| C 6 | 38 | 12·07 | 7 | 15 | 25·28 | 19 | 29 | 58·50 | 50 | 66 | 52·21 | 44 | 62 |
| C 7 | 98 | 13·44 | 10 | 17 | 29·24 | 23 | 36 | 67·95 | 59 | 80 | 58·75 | 51 | 70 |
| D 1 | 110 | 15·45 | 12 | 19 | 30·40 | 22 | 37 | 74·71 | 57 | 89 | 61·24 | 52 | 71 |
| D 2 | 40 | 17·06 | 13 | 21 | 31·17 | 20 | 37 | 72·54 | 58 | 80 | 65·69 | 53 | 72 |
| D 3 | 37 | 17·22 | 13 | 22 | 29·48 | 23 | 36 | 65·53 | 54 | 78 | 64·72 | 54 | 73 |
| D 4 | 37 | 17·78 | 15 | 22 | 27·30 | 22 | 32 | 63·04 | 52 | 74 | 65·72 | 55 | 76 |
| D 5 | 36 | 18·06 | 12 | 21 | 27·68 | 22 | 30 | 63·35 | 51 | 69 | 66·64 | 56 | 79 |
| D 6 | 35 | 18·34 | 15 | 22 | 27·77 | 22 | 33 | 63·58 | 54 | 69 | 67·83 | 58 | 77 |
| D 7 | 36 | 18·75 | 13 | 22 | 28·64 | 23 | 34 | 64·39 | 54 | 77 | 69·63 | 58 | 80 |
| D 8 | 36 | 19·18 | 16 | 23 | 30·42 | 24 | 35 | 62·49 | 52 | 70 | 69·86 | 60 | 80 |
| D 9 | 36 | 20·28 | 16 | 25 | 32·12 | 24 | 38 | 64·24 | 52 | 71 | 71·43 | 60 | 84 |
| D 10 | 53 | 21·21 | 16 | 26 | 34·02 | 26 | 38 | 58·49 | 49 | 67 | 70·56 | 58 | 81 |
| D 11 | 95 | 22·18 | 16 | 27 | 35·83 | 27 | 45 | 53·24 | 44 | 66 | 70·98 | 58 | 86 |
| D 12 | 104 | 23·15 | 17 | 29 | 37·97 | 30 | 50 | 47·86 | 38 | 63 | 73·21 | 61 | 89 |
| L 1 | 38 | 24·38 | 19 | 29 | 39·17 | 28 | 44 | 72·55 | 58 | 88 | 78·58 | 65 | 87 |
| L 2 | 39 | 25·53 | 20 | 32 | 41·14 | 28 | 45 | 80·23 | 64 | 93 | 81·94 | 69 | 92 |
| L 3 | 38 | 26·64 | 21 | 32 | 42·79 | 31 | 51 | 89·05 | 69 | 108 | 83·54 | 70 | 95 |
| L 4 | 37 | 26·78 | 21 | 32 | 44·89 | 35 | 53 | 83·62 | 63 | 102 | 82·30 | 69 | 94 |
| L 5 | 113 | 27·81 | 23 | 34 | 47·97 | 39 | 58 | 86·00 | 68 | 108 | 76·53 | 61 | 96 |

### *Summary of relations of diameters.*

| | Body A.V.D. to T.D. | | | Body A.V.D. to A-P.D. | | | Body L.D. to T.D. | | | Body L.D. to A-P.D. | | | T.D. to A-P.D. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average % | Min. | Max. | Average % | Min. | Max. | Average % | Min. | Max. | Average % | Min. | Max. | Average % | Min. | Max. |
| C 1 | — | — | — | — | — | — | — | — | — | — | — | — | 172 | 144 | 195 |
| C 2 | 71 | 58 | 89 | 79 | 62 | 95 | — | — | — | — | — | — | 107 | 92 | 129 |
| C 3 | 24 | 18 | 30 | 29 | 22 | 37 | 39 | 32 | 47 | 47 | 35 | 56 | 119 | 109 | 132 |
| C 4 | 23 | 15 | 27 | 28 | 17 | 34 | 39 | 33 | 48 | 47 | 41 | 56 | 122 | 102 | 145 |
| C 5 | 21 | 16 | 27 | 26 | 19 | 32 | 40 | 35 | 49 | 47 | 37 | 55 | 120 | 98 | 140 |
| C 6 | 21 | 14 | 24 | 23 | 15 | 30 | 43 | 35 | 57 | 48 | 39 | 61 | 112 | 95 | 136 |
| C 7 | 20 | 15 | 25 | 23 | 18 | 28 | 43 | 33 | 53 | 50 | 42 | 61 | 116 | 98 | 135 |
| D 1 | 21 | 16 | 28 | 25 | 20 | 32 | 41 | 34 | 49 | 48 | 40 | 62 | 122 | 97 | 142 |
| D 2 | 25 | 19 | 29 | 27 | 21 | 32 | 43 | 33 | 51 | 47 | 36 | 56 | 114 | 100 | 126 |
| D 3 | 26 | 22 | 35 | 27 | 22 | 32 | 45 | 36 | 55 | 46 | 37 | 51 | 101 | 87 | 114 |
| D 4 | 28 | 23 | 36 | 27 | 24 | 35 | 43 | 38 | 53 | 42 | 34 | 49 | 96 | 80 | 111 |
| D 5 | 29 | 19 | 37 | 27 | 20 | 33 | 44 | 36 | 48 | 42 | 30 | 47 | 96 | 83 | 110 |
| D 6 | 29 | 24 | 35 | 27 | 23 | 32 | 45 | 39 | 50 | 41 | 35 | 48 | 94 | 76 | 104 |
| D 7 | 29 | 22 | 37 | 27 | 20 | 31 | 44 | 32 | 52 | 41 | 30 | 49 | 93 | 68 | 106 |
| D 8 | 31 | 25 | 39 | 27 | 21 | 35 | 49 | 42 | 56 | 44 | 36 | 50 | 90 | 78 | 103 |
| D 9 | 33 | 26 | 42 | 28 | 24 | 37 | 52 | 37 | 61 | 45 | 37 | 52 | 87 | 69 | 103 |
| D 10 | 36 | 30 | 49 | 30 | 25 | 39 | 58 | 48 | 70 | 48 | 41 | 65 | 83 | 70 | 93 |
| D 11 | 43 | 30 | 55 | 31 | 23 | 43 | 67 | 53 | 92 | 50 | 42 | 60 | 75 | 57 | 90 |
| D 12 | 49 | 35 | 71 | 32 | 26 | 41 | 79 | 56 | 98 | 52 | 40 | 67 | 63 | 49 | 87 |
| L 1 | 34 | 25 | 47 | 31 | 25 | 42 | 54 | 45 | 67 | 49 | 43 | 58 | 92 | 79 | 109 |
| L 2 | 32 | 24 | 45 | 31 | 24 | 43 | 51 | 43 | 59 | 50 | 41 | 57 | 98 | 86 | 116 |
| L 3 | 30 | 22 | 38 | 32 | 27 | 40 | 48 | 34 | 61 | 51 | 44 | 65 | 107 | 91 | 127 |
| L 4 | 32 | 24 | 42 | 33 | 27 | 40 | 54 | 43 | 72 | 55 | 46 | 69 | 102 | 84 | 121 |
| L 5 | 32 | 23 | 51 | 36 | 30 | 46 | 56 | 43 | 65 | 63 | 48 | 77 | 112 | 84 | 144 |

and *vice versa*. All that can be said with certainty is that the greater number of bones were from male subjects.

Endeavours on my part to work out formulae derived from one or more measurements or ratios, from which to estimate others, were quite unsuccessful.

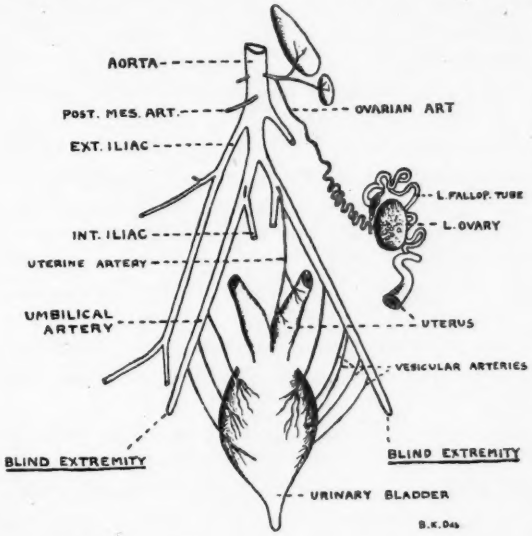
## CONCLUSIONS

My results agreed fairly closely with those of Anderson and Dwight; in many cases they corresponded exactly and in many others differences of only 1 mm. were encountered. The only differences greater than 3 mm. were: 5 mm. as regards the lateral diameters of the bodies of the last two lumbar vertebrae and 5 mm. as regards the transverse diameter of the whole bone in the fifth lumbar vertebra. The reader is referred to the original measurements of the authors mentioned for more detailed comparison.

# NOTE ON THE PERSISTENCE OF THE UMBILICAL ARTERIES AS BLINDLY-ENDING TRUNKS OF UNIFORM DIAMETER IN THE INDIAN DOMESTIC GOAT

By W. N. F. WOODLAND, D.Sc., I.E.S.,
*Muir Central College, Allahabad, U.P., India.*

My attention was first drawn to this peculiar condition of the umbilical arteries in the Indian domestic goat when five kids (two females and three males) were being dissected at an examination in Allahabad. In all of these five kids the umbilical arteries, each invested in a fold of the peritoneum and loosely attached to the wall of the urinary bladder, were as shown in the accompanying figure (kindly drawn for me by Mr B. K. Das, M.Sc.). Each




umbilical artery is given off, as in the sheep, from the base of the internal iliac, from which point of origin the uterine artery also arises. In the sheep and many other Mammals the umbilical artery is merely represented by its branches to the bladder, the original main trunk at most persisting (in the horse[1] and cat[2], e.g.) as a "fibrous cord" extending to the fundus of the bladder

[1] See *The Comparative Anatomy of the Domesticated Animals*, by A. Chauveau, 1891.

[2] St George Mivart, *The Cat*, 1881; also the *Anatomy of the Cat*, by J. Reighard and H. S. Jennings, 1901.

and navel, but in the common Indian goat each umbilical artery maintains a uniform diameter (nearly twice the size of the artery labelled internal iliac) for about 5 cms. and then suddenly ends blindly in the manner shown. From three to five vesicular arteries are given off towards the end of each umbilical artery. This same condition of the umbilical arteries was also found to exist in two other kids (sex unrecorded) and in adult goats (two specimens examined, both males). I injected several of these umbilical arteries with carmine fluid to determine if any outlet existed at the extremities but all results were negative.

The number of individuals, without exception, in which these peculiar umbilical arteries were found precludes the idea that they are individual abnormalities, and this fact may prove of some use in practice, since these umbilical arteries, occurring in such a common animal, would, as Professor Bayliss suggested to me, be extremely serviceable in connection with blood pressure experiments. I have not been able to discover any other instances in Vertebrates of arteries ending blindly in this fashion.

# FISSURAL PATTERN IN FOUR ASIATIC BRAINS

By SYDNEY J. COLE, M.A., M.D. (Oxon.),
*Medical Superintendent of the Wilts County Asylum, Devizes.*

The specimens here delineated are from the racial series in the Museum of the Royal College of Surgeons of England, and for the privilege of examining them I am indebted to the kindness of Professor Keith.

They consist of a Chinese brain, a Japanese, a Goanese, and an Arabian.

The drawings have been prepared in exactly the same way as those of three Chinese brains given in my paper in this *Journal* in 1911 (vol. xlvi, p. 54). That is to say, the pictures of the mesial and basal surfaces are tracings from photographs, modified only so far as to indicate, by a slight break in the line of a sulcus, the presence and position of any bridging gyrus concealed within it. The picture of the convex surface, on the other hand, besides giving such indications of deep gyri, departs so much in another respect from photographic outline that it has become "a sort of Mercator's projection" after Kohlbrugge's manner[1]. From a photograph of the lateral aspect of the hemisphere, taken perpendicularly to a sagittal plane, a tracing has been made, which has then by freehand drawing been extended upwards and at both ends so that the resulting picture, besides showing all that appeared in full view in the preliminary photograph, gives an equally full view of the vertex of the hemisphere and of the frontal and occipital poles. The upper border of the drawing accordingly represents, not the crest of the hemisphere as seen from the side, but the flat part of the mesial surface as seen edgeways from above. In the process of extending the drawing, the circumferential pole-to-pole dimensions of the parts all along the crest of the hemisphere have been unavoidably exaggerated; but their transverse dimensions, radial in the drawing, have been kept to the original scale. Except by some such device as this, a comprehensive record of the fissural pattern could not be given without cumbersome and costly multiplication of pictures from numerous points of view.

The Arabic figures upon the drawings give the approximate depth of the sulci in millimetres at the points against which they are placed. The Roman figures are marks by which we may identify corresponding points in two views of the same hemisphere.

I give no formal description of the specimens, but notes on some points which the pictures themselves do not reveal. No weights are given; they would be valueless, if only because the strength of the hardening fluids employed is not known, nor how long the specimens had remained first in formalin and then in spirit. The maximum sagittal diameter of the hardened hemisphere, taken in conjunction with the pictures of the mesial and basal surfaces, permits, however, a rough estimate of size. The other customary

[1] J. H. F. Kohlbrugge, *Die Gehirnfurchen Malayischer Völker*, Amsterdam, 1909, p. 11.

measurements are dispensed with, partly because of some distortion of the specimens, but also on general grounds, notably the want of fixed points, from which alone such measurements, if they are to have value, can be taken.

CHINESE BRAIN D (figs. 1–5). Yu Ling, male, aet. 29, South China.

*Left Hemisphere.*—Maximum sagittal diameter, 163 mm.

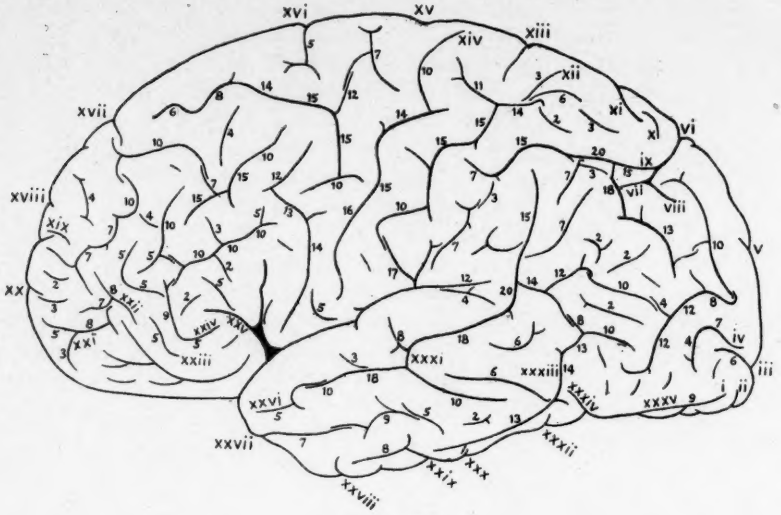


Fig. 1. D.

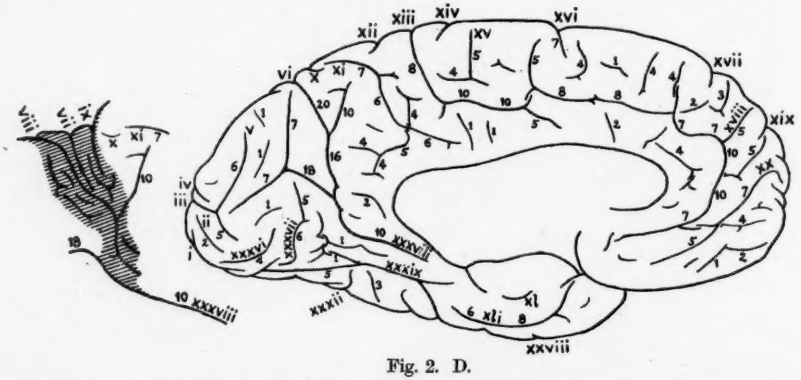


Fig. 2. D.

In the border of the orbital operculum there is one considerable notch, having the shape of an obtuse angle.

A little behind the lower end of the sulcus centralis, the border of the fronto-parietal operculum shows a notch, the end of a furrow that runs out from the superior limiting sulcus of the insula.

The incisura parieto-occipitalis (vii) extends outwards to join the intraparietal sulcus, but the depth to which it cuts the superior surface of the arcus parieto-occipitalis is only about 4 mm.

The intraparietal sulcus shows the oft-described appearance of three arches, but, as will be seen from the drawing, the middle arch is specious merely.

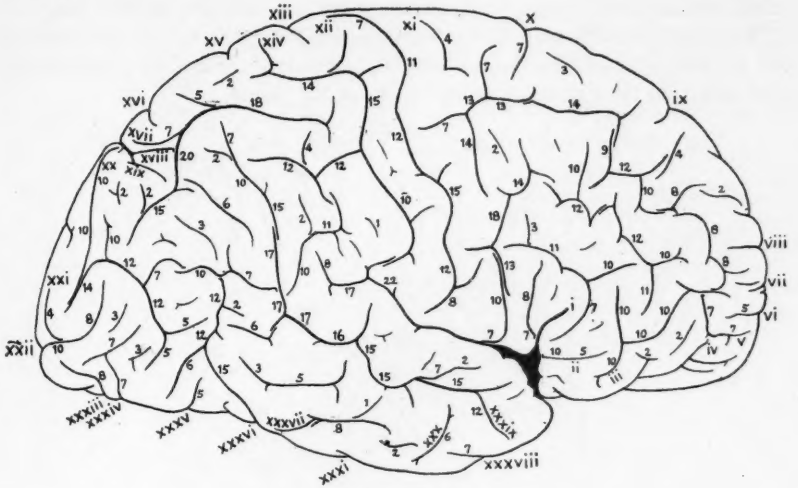


Fig. 3. D.

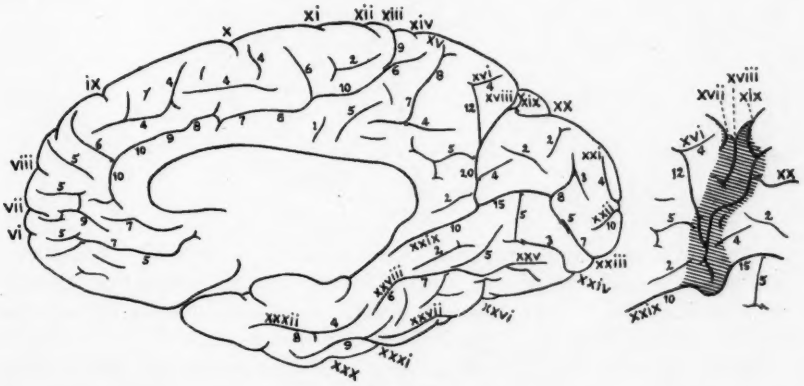


Fig. 4. D.

There are pronounced interdigitations in the superior and inferior frontal sulci; in the sulcus centralis, throughout its length; in the sulcus temporalis superior, especially near the origin of a posterior branch 14 mm. deep; and in the sulcus lunatus. Interdigitations are well marked in all that part of the sulcus cinguli anterior to Eberstaller's Brücke 3, especially at the place where

Brücke 2 would be looked for; at this place the interdigitations are associated with the appearance of notches in the lips of the sulcus; these notches are indicated in fig. 2.

The gyrus cunei is well developed.

*Right Hemisphere.*—Maximum sagittal diameter, 163 mm.

In the border of the orbital operculum, about opposite the middle of the sulcus orbitalis transversus of Weisbach, there is a pair of small notches.

Far back on the border of the fronto-parietal operculum, and indicated in the drawing just below a depth-mark 22, is a notch, the end of a sulcus that runs out from the superior limiting sulcus of the insula.

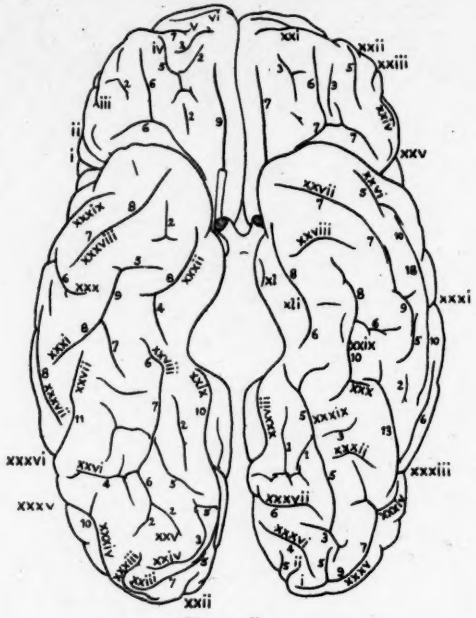


Fig. 5 D.

The incisura parieto-occipitalis (xviii) runs out to join the intraparieta sulcus, and cuts the superior surface of the arcus parieto-occipitalis to a depth nowhere less than 14 mm. There is a well-defined arcus intercuneatus turning beneath the inner end of the incisura (see inset to fig. 4).

The posterior end of the sulcus occipitalis paramesialis (xx) has a rather deep confluence with the upper end of the sulcus lunatus. The posterior lip of the sulcus lunatus overhangs the anterior lip in opercular fashion.

Interdigitations are well marked throughout the intraparietal, postcentral, superior temporal and superior frontal sulci; less well marked all along the sulcus centralis.

The gyrus cunei is well developed.

JAPANESE BRAIN (figs. 6–10). Male.

*Left Hemisphere.*—Maximum sagittal diameter, 151 mm.

The Sylvian fissure has a small anterior horizontal limb; and nearly oppo-

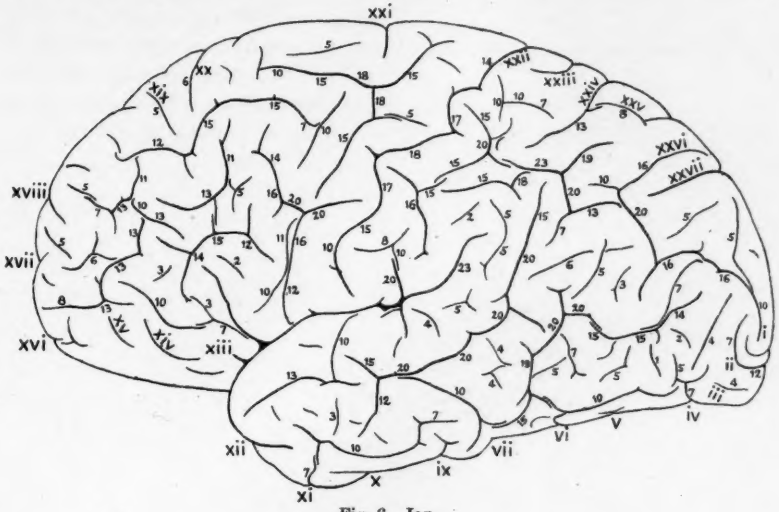


Fig. 6. Jap.

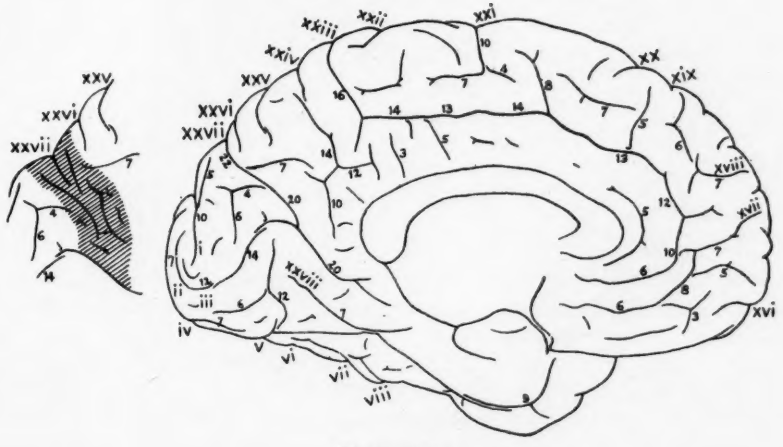


Fig. 7. Jap.

site the middle of the sulcus orbitalis transversus the border of the orbital operculum has a small notch (indicated in fig. 10).

Behind the lower end of the sulcus centralis, the border of the fronto-parietal operculum shows a small notch, the end of a furrow that runs straight

out from the superior limiting sulcus of the insula. The sulcus 20 mm. deep, immediately behind this notch, fails to reach the superior limiting sulcus.

Heschl's transverse gyri are well developed.

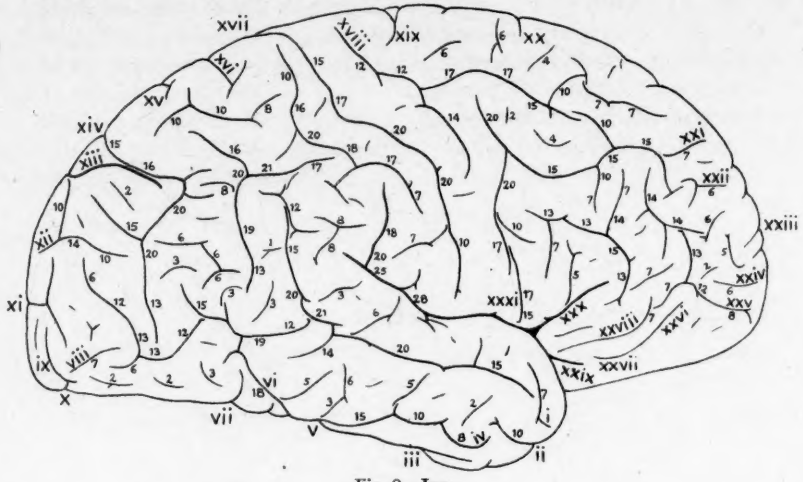


Fig. 8. Jap.

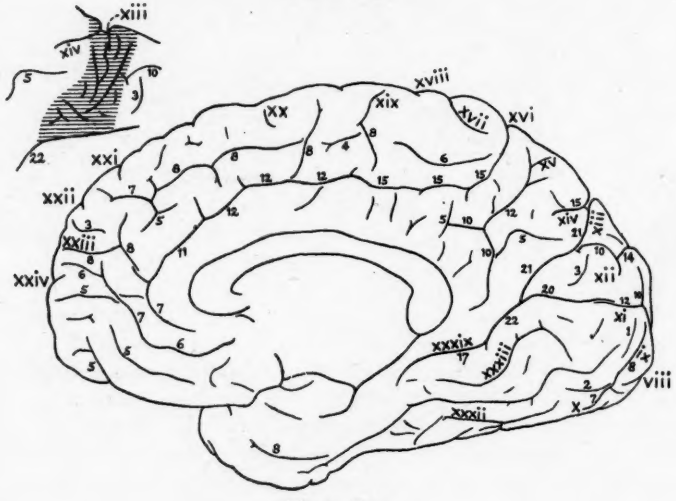


Fig. 9. Jap.

All the deep gyri indicated in fig. 6 in the intraparietal and postcentral sulci are very well defined. Interdigitations are strongly marked in the intraparietal, superior postcentral, superior precentral and superior frontal sulci, and throughout the sulcus centralis. There is an absence of deep bridging gyri in the sulcus cinguli, but there are many slight interdigitations.

On the inner aspect of the occipital pole is a well defined impression of the superior longitudinal venous sinus. The upturned end of the calcarine sulcus lies in this impression, and so comes to appear in fig. 6, but it does not invade the convexity proper.

The gyrus cunei is well developed.

The rhinal fissure has shallow confluence with the incisura temporalis and with the collateral sulcus.

*Right Hemisphere.*—Maximum sagittal diameter, 148 mm.

There are no notches in the border of the orbital operculum.

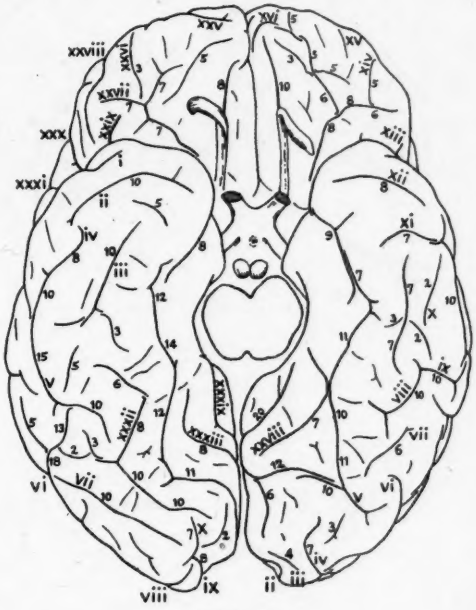


Fig. 10. Jap.

In the border of the fronto-parietal operculum are seen two notches, the terminations of two furrows that run out from the superior limiting sulcus. One appears near "xxxi," and the other just behind "28."

Heschl's transverse gyri are well developed.

Interdigitations are fairly well marked in the middle third of the sulcus centralis, and throughout the sulcus frontalis superior. They are well developed throughout the precentral, postcentral and superior temporal sulci. There is an absence of deep gyri in the sulcus cinguli.

In the parieto-occipital fossa there is no definite arcus intercuneatus.

The gyrus cunei is fairly well developed.

In each hemisphere the sulcus rhinencephali inferior of Retzius is faintly marked.

BRAIN OF A NATIVE OF GOA, India (figs. 11–15). Male. Age unknown, "but not old."

*Left Hemisphere.*—Maximum sagittal diameter, 169 mm.

In the border of the orbital operculum there is one considerable notch, situated in a sagittal plane about 5 mm. internal to the outer extremity of the sulcus orbitalis transversus.

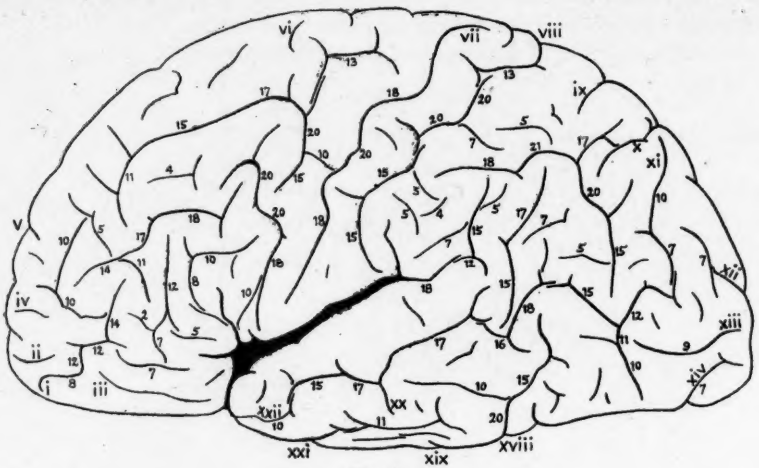



Fig. 11. Goa.

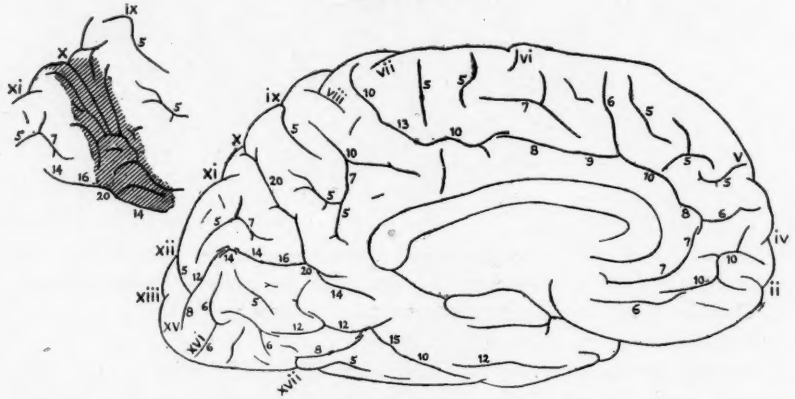



Fig. 12. Goa.

The upper end of the sulcus diagonalis has a superficial connection with the inferior precentral sulcus, and its lower end runs into the anterior ascending Sylvian limb.

In the internal arrangements of the parieto-occipital fossa there is some suggestion of an arcus intercuneatus and its accompanying sulci. In fig. 11 a

notch is shown which establishes a superficial connection between the parieto-occipital fissure and an ascending branch of the intraparietal sulcus lying close in front of it. This branch is partly shown also in the inset to fig. 12,

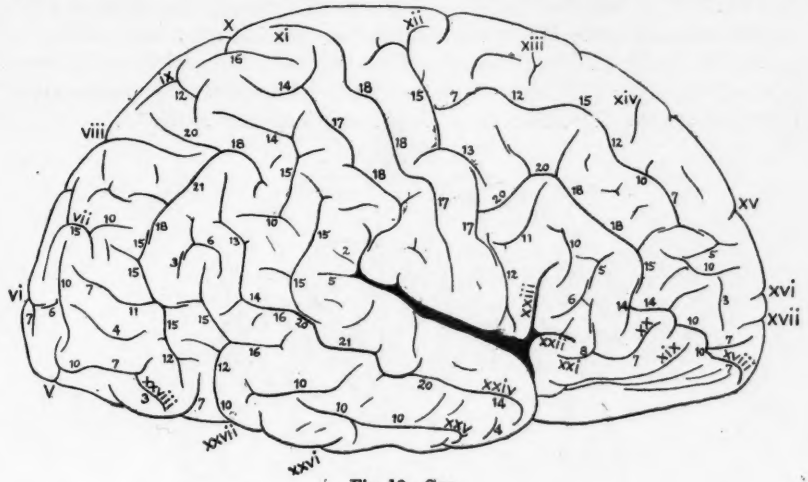


Fig. 13. Goa.

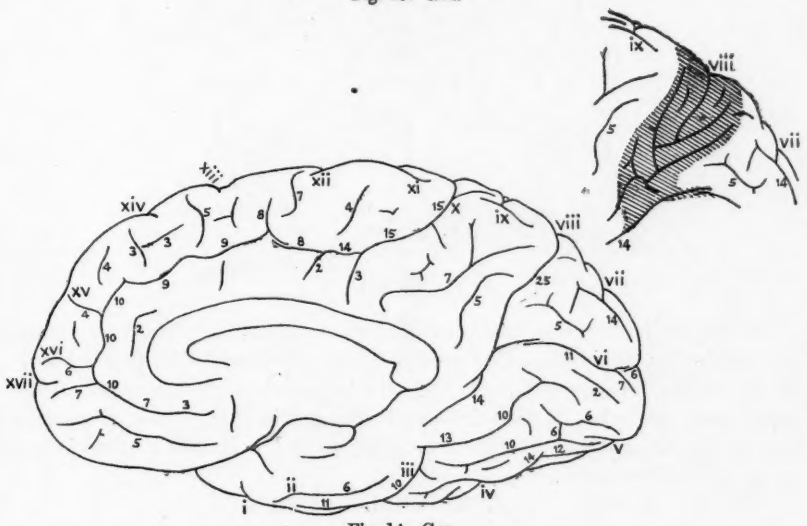


Fig. 14. Goa.

where the above-mentioned notch may be seen descending from it a short distance into the parieto-occipital fossa (shaded area).

The gyrus cunei is very well developed.

Interdigitations are strongly marked in the intraparietal, postcentral and

inferior precentral sulci; well marked in the sulcus temporalis superior and all along the sulcus centralis; less well marked in the sulcus frontalis superior.

The rhinal fissure is well developed, and joins the incisura temporalis (fig. 12).

*Right Hemisphere.*—Maximum sagittal diameter, 166 mm.

In the border of the orbital operculum there are two slight notches, one in a sagittal plane with each of the two anterior branches of the sulcus orbitalis transversus. The inner one of these notches appears in fig. 15.

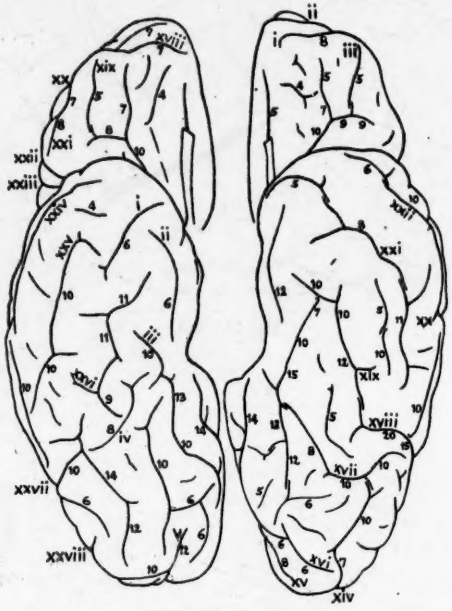


Fig. 15. Goa.

Rather far back on the border of the fronto-parietal operculum is a notch, the termination of a furrow that runs out from the superior limiting sulcus.

Interdigitations are well marked in the intraparietal, postcentral and superior temporal sulci, in the sulcus centralis, and in that part of the sulcus cinguli that lies anterior to Brücke 2. They are not very well marked in the sulcus frontalis superior.

The gyrus cunei is very well developed.

Brain of a Native of Arabia (figs. 16–20). Hamid Naggi, male, aet. 30. "Dark, and probably half negro." Died in England, of tuberculosis and peritonitis.

Presumably to facilitate penetration by the hardening fluid, the mesial surface of each hemisphere has been incised and the gash stuffed with wool,

crushing the corpus callosum and adjacent parts. In figs. 17 and 19, the gaping chasms are shown in solid black, across which some broken white lines have been drawn to connect portions of sulci properly continuous.

*Left Hemisphere.*—Maximum sagittal diameter, 166 mm.

Besides the large anterior ascending limb of the Sylvian fissure there is a small anterior horizontal limb (figs. 16 and 20). There are no notches in the border of the orbital operculum.

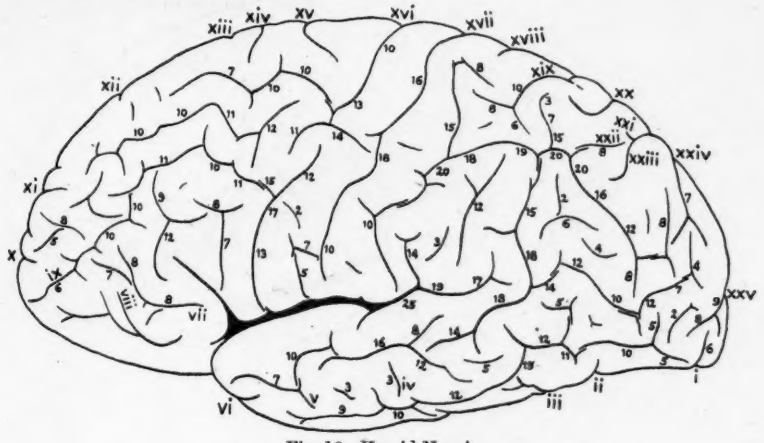


Fig. 16. Hamid Naggi.

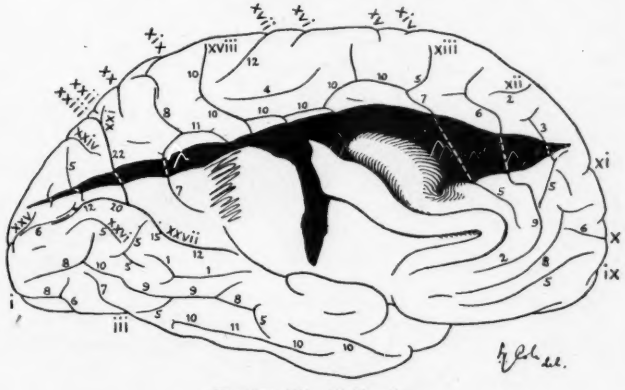


Fig. 17. Hamid Naggi.

In the border of the fronto-parietal operculum, a little behind the lower end of the sulcus centralis, there is a notch, the termination of a furrow that runs out from the superior limiting sulcus.

Interdigitations are present throughout the sulcus centralis. They are well marked in the superior and middle frontal sulci, the postcentral and intraparietal sulci, and the superior and middle temporal sulci.

The gyrus cunei is well developed.

The sulcus rhinencephali inferior is fairly well defined.

*Right Hemisphere.*—Maximum sagittal diameter, 163 mm.

The outer root of the sulcus olfactorius has a superficial connection with a sulcus which runs outwards and forwards towards the middle of the sulcus orbitalis transversus.

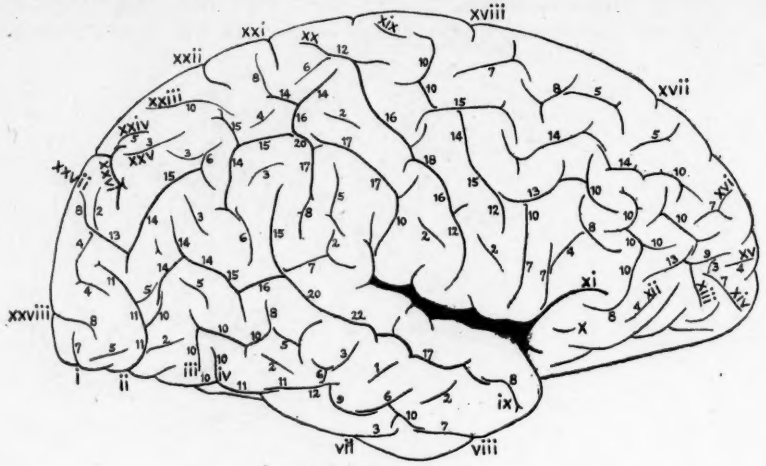



Fig. 18. Hamid Naggi.

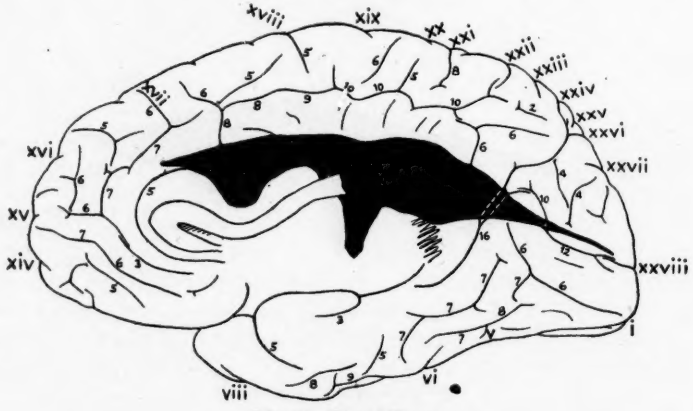



Fig. 19. Hamid Naggi.

There is a large anterior ascending limb of the Sylvian fissure (xi). And there is an orbital limb, which in the basal view (fig. 20) is seen emerging from beneath the temporal pole, behind that point in the sulcus orbitalis transversus against which a depth-mark 8 is placed.

The border of the fronto-parietal operculum is notched by two small sulci, one a little behind and the other a little in front of the lower end of the sulcus centralis. The posterior of these runs out from the superior limiting sulcus

The anterior, just within the Sylvian fissure, has a shallow connection with a sulcus that joins the superior limiting sulcus.

Interdigitations are well marked in the superior frontal and superior temporal sulci. They are present throughout the sulcus centralis. They are less pronounced in the intraparietal sulcus.

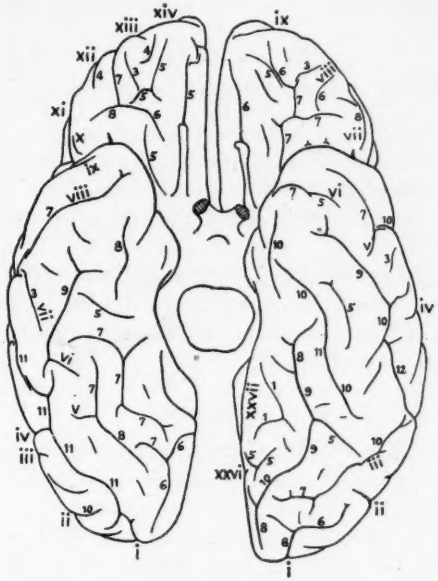


Fig. 20. Hamid Naggi.

The posterior lip of the sulcus lunatus overhangs the anterior lip considerably, in opercular fashion. On raising it, a bold buttress is seen on the anterior wall of the sulcus, immediately above the origin of an anterior branch 10 mm. deep.

The gyrus cunei is well developed.

The sulcus rhinencephali inferior is faintly marked.

# FURTHER OBSERVATIONS ON THE GASTRO-INTESTINAL TRACT OF THE HINDUS

By Dr N. PAN,

*Professor of Anatomy, Medical College, Calcutta, India*

In my last paper published in the *Journal of Anatomy* (vol. LIII. Parts 2 and 3, April, 1919), I embodied the results of my observations on 65 cases. Subsequently, I continued my observations in the same line on additional 84 cases and the conclusions derived from the first series of 65 cases have been mostly corroborated.

The subjects in the present series are also Hindus, living on bulky Carbohydrate food. The method of preservation has been the same, viz., a preliminary injection of 8 oz. of Formalin after death followed after 24 hours by an injection of a solution of Arsenic.

## STOMACH

*Capacity of the Stomach.* In Table A, the stomachs of both males and females have been arranged in order of increasing capacity. It shows that the capacity is very variable, ranging from 6 oz. to 200 oz., giving an average of 75 oz. In 54 out of these 84 cases (i.e. in 64 per cent.) the capacity is over 50 oz. Taking the two series of cases together (65 + 84 = 149 cases) the average capacity comes to 73·5 oz. Thus in Hindus, the average capacity of the stomach is much bigger than in Europeans and may be definitely said to lie between 70 and 80 oz.

In Table B, female stomachs have been arranged in order of increasing capacity. In this series, there are 23 subjects and the capacity ranges from 8 to 154 oz., giving an average of 59 oz. In my first series of 29 female subjects, the average capacity was 60 oz. Taking the two series together the average comes to 59·7 oz.

In Table C, stomachs of male subjects have been arranged in order of increasing capacity. The capacity ranges from 6 to 200 oz., giving an average of 81 oz. In my first series of 36 male subjects the average capacity was 80½ oz. So the results of the two series tally with each other very closely. Now, it may be definitely stated that the capacity of male stomachs is much bigger than that of the female stomachs. In females, the average capacity is 60 oz., whereas, in males it is roughly 80 oz. This difference in the capacity of the stomachs in the two sexes may be explained by observing the social custom of the Hindus. The members of a family take their food in batches; the male members take their meals first, and the female members in the last batch,

Table A.

*Stomachs of both sexes arranged in order of increasing capacity.*

| No. | Sex | Length in inches | Greatest width in inches | Capacity in ounces | No. | Sex | Length in inches | Greatest width in inches | Capacity in ounces |
|---|---|---|---|---|---|---|---|---|---|
| 1 | M. | 7 | 3 | 6 | 43 | M. | 12 | 6 | 80 |
| 2 | M. | 7½ | 4½ | 7½ | 44 | M. | 11½ | 5 | 80 |
| 3 | F. | 7½ | 4 | 8 | 45 | M. | 11 | 6 | 80 |
| 4 | F. | 7 | 4 | 9 | 46 | F. | 11 | 6 | 80 |
| 5 | F. | 7 | 2½ | 10 | 47 | M. | 12½ | 5 | 80 |
| 6 | M. | 5½ | 4 | 12 | 48 | M. | 11 | 7 | 82 |
| 7 | F. | 8 | 4 | 12 | 49 | M. | 11 | 7 | 85 |
| 8 | F. | 8 | 5 | 14 | 50 | M. | 12 | 6 | 88 |
| 9 | M. | 8 | 4 | 15 | 51 | M. | 12 | 8 | 93 |
| 10 | M. | 7 | 3½ | 16 | 52 | F. | 12 | 7 | 96 |
| 11 | F. | 9½ | 4 | 21 | 53 | M. | 11 | 7 | 96 |
| 12 | M. | 7½ | 4½ | 22 | 54 | F. | 11 | 6 | 96 |
| 13 | F. | 10 | 4½ | 22 | 55 | M. | 11½ | 6 | 96 |
| 14 | M. | 6 | 4 | 24 | 56 | F. | 12 | 7 | 96 |
| 15 | M. | 7¼ | 4¼ | 25 | 57 | M. | 15 | 5 | 98 |
| 16 | M. | 10 | 4½ | 30 | 58 | M. | 12 | 5 | 102 |
| 17 | F. | 8 | 5 | 32 | 59 | M. | 11 | 7 | 104 |
| 18 | M. | 10 | 6 | 32 | 60 | M. | 12½ | 6½ | 104 |
| 19 | F. | 9½ | 5 | 33 | 61 | M. | 13 | 6½ | 104 |
| 20 | M. | 10 | 5 | 40 | 62 | M. | 12¼ | 6 | 104 |
| 21 | M. | 8½ | 5 | 40 | 63 | M. | 13 | 8 | 104 |
| 22 | F. | 11 | 7 | 40 | 64 | M. | 12 | 8 | 105 |
| 23 | F. | 8 | 4½ | 41 | 65 | M. | 13 | 6 | 105 |
| 24 | M. | 10 | 4¾ | 43 | 66 | F. | 12 | 8 | 105 |
| 25 | M. | 9½ | 5 | 43 | 67 | M. | 13 | 6 | 106 |
| 26 | M. | 9 | 5 | 45 | 68 | M. | 14 | 8 | 106 |
| 27 | M. | 8½ | 4½ | 46 | 69 | M. | 14 | 6 | 109 |
| 28 | M. | 10 | 7 | 48 | 70 | M. | 13 | 8 | 110 |
| 29 | F. | 9 | 5 | 48 | 71 | M. | 14 | 8 | 110 |
| 30 | M. | 11 | 8 | 48 | 72 | M. | 15 | 8 | 112 |
| 31 | M | 12 | 5 | 58 | 73 | F. | 16 | 9 | 119 |
| 32 | F. | 9 | 5 | 58 | 74 | M. | 12 | 9 | 120 |
| 33 | F. | 8 | 6 | 60 | 75 | M. | 14 | 5½ | 130 |
| 34 | M. | 12 | 5 | 60 | 76 | M. | 14½ | 6½ | 132 |
| 35 | M. | 9 | 5 | 62 | 77 | F. | 14½ | 5½ | 132 |
| 36 | M. | 12 | 3½ | 62 | 78 | M. | 12½ | 8 | 135 |
| 37 | M. | 10 | 5½ | 68 | 79 | M. | 15 | 11 | 139 |
| 38 | F. | 10 | 6 | 70 | 80 | M. | 17 | 6 | 144 |
| 39 | M. | 11½ | 7 | 70 | 81 | F. | 15½ | 8½ | 154 |
| 40 | M. | 12 | 6½ | 70 | 82 | M. | 14 | 8 | 180 |
| 41 | M. | 10½ | 6 | 72 | 83 | M. | 15 | 9 | 180 |
| 42 | M. | 12 | 7 | 80 | 84 | M. | 20 | 7 | 200 |

Table B.

*Female stomachs arranged in order of increasing capacity.*

| No. | Length in inches | Greatest width in inches | Capacity in ounces | No. | Length in inches | Greatest width in inches | Capacity in ounces |
|---|---|---|---|---|---|---|---|
| 1 | 7½ | 4 | 8 | 13 | 9 | 5 | 58 |
| 2 | 7 | 4 | 9 | 14 | 8 | 6 | 60 |
| 3 | 7 | 2½ | 10 | 15 | 10 | 6 | 70 |
| 4 | 8 | 4 | 12 | 16 | 11 | 6 | 80 |
| 5 | 8 | 5 | 14 | 17 | 11 | 6 | 96 |
| 6 | 9½ | 4 | 21 | 18 | 12 | 7 | 96 |
| 7 | 10 | 4½ | 22 | 19 | 12 | 7 | 96 |
| 8 | 8 | 5 | 32 | 20 | 12 | 8 | 105 |
| 9 | 9½ | 5 | 33 | 21 | 16 | 9 | 119 |
| 10 | 11 | 7 | 40 | 22 | 14½ | 5½ | 132 |
| 11 | 8 | 4½ | 41 | 23 | 15½ | 8½ | 154 |
| 12 | 9 | 5 | 48 | | | | |

Table C.

*Male stomachs arranged in order of increasing capacity.*

| No. | Length in inches | Greatest width in inches | Capacity in ounces | No. | Length in inches | Greatest width in inches | Capacity in ounces |
|---|---|---|---|---|---|---|---|
| 1 | 7 | 3 | 6 | 32 | 11 | 7 | 82 |
| 2 | 7½ | 4½ | 7½ | 33 | 11 | 7 | 85 |
| 3 | 5½ | 4 | 12 | 34 | 12 | 6 | 88 |
| 4 | 8 | 4 | 15 | 35 | 12 | 8 | 93 |
| 5 | 7 | 3½ | 16 | 36 | 11 | 7 | 96 |
| 6 | 7½ | 4½ | 22 | 37 | 11½ | 6 | 96 |
| 7 | 6 | 4 | 24 | 38 | 15 | 5 | 98 |
| 8 | 7¼ | 4¼ | 25 | 39 | 12 | 5 | 102 |
| 9 | 10 | 4½ | 30 | 40 | 11 | 7 | 104 |
| 10 | 10 | 6 | 32 | 41 | 12½ | 6½ | 104 |
| 11 | 10 | 5 | 40 | 42 | 13 | 6½ | 104 |
| 12 | 8½ | 5 | 40 | 43 | 12¾ | 6 | 104 |
| 13 | 10 | 4¾ | 43 | 44 | 13 | 8 | 104 |
| 14 | 9½ | 5 | 43 | 45 | 12 | 8 | 105 |
| 15 | 9 | 5 | 45 | 46 | 13 | 6 | 105 |
| 16 | 8½ | 4½ | 46 | 47 | 13 | 6 | 106 |
| 17 | 10 | 7 | 48 | 48 | 14 | 8 | 106 |
| 18 | 11 | 8 | 48 | 49 | 14 | 6 | 109 |
| 19 | 12 | 5 | 58 | 50 | 13 | 8 | 110 |
| 20 | 12 | 5 | 60 | 51 | 14 | 8 | 110 |
| 21 | 9 | 5 | 62 | 52 | 15 | 8 | 112 |
| 22 | 12 | 3½ | 62 | 53 | 12 | 9 | 120 |
| 23 | 10 | 5½ | 68 | 54 | 14 | 5½ | 130 |
| 24 | 11½ | 7 | 70 | 55 | 14½ | 6½ | 132 |
| 25 | 12 | 6½ | 70 | 56 | 12½ | 8 | 135 |
| 26 | 10½ | 6 | 72 | 57 | 15 | 11 | 139 |
| 27 | 12 | 7 | 80 | 58 | 17 | 6 | 144 |
| 28 | 12 | 6 | 80 | 59 | 14 | 8 | 180 |
| 29 | 11½ | 5 | 80 | 60 | 15 | 9 | 181 |
| 30 | 11 | 6 | 80 | 61 | 20 | 7 | 200 |
| 31 | 12½ | 5 | 80 | | | | |

partake of the remains of a meal which are usually insufficient. Thus they are often underfed, resulting in a reduction in size of their stomachs.

My observations on the stomachs of stillborn full term foetuses are yet incomplete.

*Measurements of Stomachs*

Table A shows the measurements in both males and females. The length varies considerably giving an average of 11·1 inches in both sexes taken together. In my first series of 65 cases, the average length was 11·25 inches. So, here also the result of my previous observation has been corroborated. As regards the breadth, the average of this series comes to 6 inches, and this corroborates my previous statement that the increase in the breadth of the stomach of the Hindus is more marked than the increase in length.

DUODENUM

Observations have been made on the same 84 subjects (Tables D and E). In both males and females taken together, the average length of the Duodenum is found to be 9·4 inches. This also tallies with the result of my previous observation, showing that the average length of the Duodenum in Hindus is less.

### JEJUNUM AND ILEUM

The average length of the Jejunum and Ileum in both males and females taken together (Tables D and E) is found to be 20 ft 7 inches. Adding to this 9·4 inches, the average length of the Duodenum, the average length of the Small Intestine is found to be 21 ft 4½ inches. This approaches closely the result of my observation on the first series of 65 cases, in which the average length came to 21 ft 9½ inches. Thus it confirms my statement that the average length of the Small Intestine of the Hindus is less than in Europeans. Taking the average length of the Small Intestine of females only (Table D), the average is found to be 19 ft 9½ inches. Here the results of the two series of female cases have been conflicting. For, in my first series of 29 female cases, the average length was found to be 22 ft 1½ inches. So no definite statement can be made regarding the length of the Small Intestine in females here, until further observations are carried out on a larger number of cases.

#### *Aggregated Lymph Nodules (Peyer's Patches)*

Taking the male and female subjects together (Tables D and E), the average number is found to be 21. Thus it confirms my statement that the average number here lies between 20 and 30.

#### *Vermiform Process*

The length of the Vermiform Process has been noted in the same 84 subjects (Tables D and E). The average length in these cases is nearly 3 inches. Taking the average of 149 cases (first and second series together) the length

Table D.

*Female subjects.*

| No. | Length of Duodenum in inches | Length of Jej. and Ileum in feet | Length of V. Appendix in inches | Number of Peyer's Patches | Length of L. Intestine in feet | Mesococcum | Mesocolon | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ascending | Descending |
| 1 | 8 | 14½ | 3 | 24 | 4½ | nil | nil | pres. |
| 2 | 7 | 13½ | 2½ | 15 | 2½ | nil | nil | nil |
| 3 | 7 | 14½ | 2 | 23 | 4½ | nil | nil | pres. |
| 4 | 10 | 19½ | 2½ | 13 | 2½ | pres. | nil | nil |
| 5 | 8 | 20½ | 2 | 8 | 4½ | nil | nil | pres. |
| 6 | 8 | 8½ | 2 | 11 | 3 | nil | nil | nil |
| 7 | 10 | 22 | 2½ | 15 | 5½ | nil | nil | nil |
| 8 | 10 | 20 | 2½ | 20 | 7 | nil | nil | nil |
| 9 | 10 | 25½ | 2½ | 33 | 4½ | nil | nil | nil |
| 10 | 8 | 18 | 2 | 17 | 3 | nil | nil | pres. |
| 11 | 8 | 20½ | 1 | 57 | 6½ | nil | nil | nil |
| 12 | 10½ | 23 | 2½ | 20 | 6 | nil | nil | nil |
| 13 | 10 | 13½ | 2½ | 20 | 3½ | nil | nil | pres. |
| 14 | 12 | 20 | 1½ | 23 | 3½ | pres. | pres. | pres. |
| 15 | 9 | 20¾ | 2¼ | 27 | 6½ | nil | pres. | pres. |
| 16 | 11½ | 12 | 2 | 8 | 4 | pres. | pres. | pres. |
| 17 | 11 | 21¼ | 4½ | 28 | 7½ | nil | nil | nil |
| 18 | 7½ | 17 | 2 | 21 | 4 | nil | nil | nil |
| 19 | 10 | 20 | 4½ | 23 | 6½ | nil | nil | nil |
| 20 | 11 | 16¼ | 5 | 14 | 5½ | nil | nil | nil |
| 21 | 12 | 21 | 4 | 13 | 6 | pres. | pres. | pres. |
| 22 | 9½ | 22 | 5 | 15 | 5 | nil | nil | nil |
| 23 | 9½ | 25 | 1½ | 13 | 4¾ | nil | pres. | pres. |

## Table E.

### *Male subjects.*

| No. | Length of Duodenum in inches | Length of J. j. and Ileum in feet | Length of V. Appendix in inches | Number of Peyer's Patches | Length of L. Intestine in feet | Mesocoecum | Mesocolon | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ascending | Descending |
| 1 | 10½ | 22 | 4 | 24 | 6 | nil | nil | nil |
| 2 | 7 | 19 | 2 | 26 | 4¼ | nil | nil | nil |
| 3 | 7 | 16¼ | 3½ | 19 | 4⅓ | nil | nil | nil |
| 4 | 7 | 24 | 2 | 23 | 4 | nil | nil | nil |
| 5 | 10 | 16½ | 2 | 5 | 3½ | pres. | pres. | pres. |
| 6 | 8 | 13½ | 2½ | 0 | 4½ | nil | nil | pres. |
| 7 | 5 | 24½ | 3 | 28 | 5¼ | nil | nil | nil |
| 8 | 11½ | 16¾ | 3 | 16 | 3¾ | nil | nil | nil |
| 9 | 10 | 18½ | 2 | 27 | 4½ | nil | nil | nil |
| 10 | 9½ | 12 | 3 | 12 | 3½ | nil | nil | nil |
| 11 | 9 | 21 | 2 | 25 | 4½ | nil | nil | nil |
| 12 | 11 | 21¾ | 3 | 8 | 5 | nil | nil | nil |
| 13 | 8 | 24 | 2 | 22 | 5 | nil | nil | nil |
| 14 | 12 | 23 | 2½ | 5 | 5¼ | nil | nil | nil |
| 15 | 10 | 16½ | 4 | 37 | 3 | nil | nil | nil |
| 16 | 9 | 22¼ | 4¾ | 12 | 4¼ | nil | nil | nil |
| 17 | 11 | 19½ | 3 | 17 | 7½ | nil | nil | nil |
| 18 | 8 | 16¾ | 3 | 19 | 3½ | nil | pres. | pres. |
| 19 | 10 | 21 | 4 | 25 | 4 | nil | nil | nil |
| 20 | 10 | 17½ | 2 | 25 | 5 | nil | nil | nil |
| 21 | 9½ | 18 | 3½ | 16 | 3¾ | nil | nil | nil |
| 22 | 9 | 21½ | 3 | 28 | 4 | nil | nil | nil |
| 23 | 7½ | 27½ | 4 | 21 | 3¾ | nil | pres. | nil |
| 24 | 10 | 21¾ | 5 | 26 | 4 | nil | nil | nil |
| 25 | 9 | 15½ | 2¾ | 20 | 4 | nil | nil | nil |
| 26 | 9 | 27½ | 2¾ | 29 | 5½ | nil | nil | nil |
| 27 | 9½ | 20 | 3 | 10 | 7 | nil | nil | nil |
| 28 | 9 | 29 | 3 | 21 | 5¼ | nil | nil | nil |
| 29 | 10 | 22 | 2½ | 25 | 6 | nil | nil | nil |
| 30 | 6 | 18 | 2 | 27 | 3 | nil | nil | nil |
| 31 | 11 | 32 | 1½ | 21 | 5½ | nil | nil | nil |
| 32 | 11½ | 19 | 3 | 25 | 4½ | pres. | pres. | pres. |
| 33 | 8 | 21½ | 4½ | 12 | 5¾ | nil | nil | nil |
| 34 | 9½ | 16 | 2½ | 29 | 4½ | nil | nil | nil |
| 35 | 8½ | 19½ | 2 | 38 | 4 | pres. | pres. | nil |
| 36 | 6 | 23½ | 2 | 34 | 4¾ | nil | nil | pres. |
| 37 | 9 | 25½ | 4 | 32 | 4½ | nil | nil | nil |
| 38 | 9 | 25 | 2½ | 20 | 4½ | nil | pres. | nil |
| 39 | 9 | 17½ | 2¾ | 18 | 4¾ | pres. | pres. | pres. |
| 40 | 10 | 13¾ | 3¼ | 3 | 3½ | nil | nil | nil |
| 41 | 12 | 19 | 2 | 25 | 5 | nil | nil | nil |
| 42 | 11½ | 24 | 4 | 23 | 5½ | nil | nil | nil |
| 43 | 8½ | 21½ | 2½ | 32 | 4 | nil | nil | nil |
| 44 | 8 | 21 | 4 | 34 | 4½ | nil | nil | nil |
| 45 | 9 | 25 | 3½ | 20 | 6½ | nil | nil | pres. |
| 46 | 11 | 22½ | 4½ | 27 | 4 | nil | nil | nil |
| 47 | 11 | 26 | 3½ | 29 | 5¼ | nil | nil | pres. |
| 48 | 11 | 24 | 4 | 34 | 4½ | nil | nil | nil |
| 49 | 8½ | 21¼ | 4 | 14 | 5 | nil | pres. | pres. |
| 50 | 12 | 27 | 2¾ | 21 | 7 | nil | nil | nil |
| 51 | 9 | 20½ | 2 | 21 | 6¼ | nil | nil | nil |
| 52 | 11½ | 25 | 1½ | 37 | 8 | nil | nil | nil |
| 53 | 10 | 17½ | 3 | 16 | 4½ | pres. | pres. | pres. |
| 54 | 9½ | 22 | 5 | 15 | 5 | nil | nil | nil |
| 55 | 10 | 22¼ | 3½ | 15 | 5 | nil | nil | nil |
| 56 | 11 | 28 | 4½ | 23 | 9 | nil | nil | pres. |
| 57 | 12 | 24½ | 3½ | 23 | 5 | nil | nil | nil |
| 58 | 9 | 25 | 3 | 27 | 4½ | nil | nil | nil |
| 59 | 8½ | 15 | 2 | 20 | 3½ | pres. | nil | nil |
| 60 | 11 | 21½ | 2 | 25 | 4½ | pres. | pres. | pres. |
| 61 | 9 | 27 | 4 | 28 | 9½ | nil | nil | nil |

of the Vermiform Process is found to be 2·8 inches. So it confirms my statement that the average length of the Vermiform Process is less in Hindus. The largest Appendix found has been 5 inches.

As regards the position of the Vermiform Process, it has been found to occupy all possible positions, viz. (1) upwards and lateralwards, (2) vertically upwards, (3) upwards and medialwards, (4) horizontally medialwards, (5) downwards and medialwards, (6) vertically downwards, (7) downwards and lateralwards, (8) horizontally lateralwards. In 63 per cent. of these cases, it has been found directed upwards. In one case, the Vermiform Process 2½ inches in length, was directed upwards and medialwards and lodged in a deep peritoneal recess. This recess was an unusual one (not the Inferior Ileocoecal pouch), and was situated below the Ileum, one inch to the left of the Ileocoecal junction, with its opening directed downwards and to the right. One and a half inches of the terminal part of the appendix was inside the pouch, and could not be drawn out as it was adherent inside the pouch, due perhaps to previous inflammation.

### COECUM

The position of the Coecum has been noted in these 84 cases. In 7 cases, it has been found in the right Lumbar region just above the crest of the Ilium. In 4 subjects, it has been found 2 inches above the medial margin of the Psoas Major, at the brim of the lesser Pelvis. In one case it was hanging into the Pelvis. In the remaining 72 cases, its position was normal in the right Iliac Fossa.

### LARGE INTESTINE including Rectum and Anal Canal

The length of the Large Intestine has been noted in the same 84 cases (Tables D and E). The length varies from 2 ft 4 inches to 9 ft 6 inches, giving an average of 4 ft 10 inches. The extremes found by other observers are not below 3 ft nor above 7 ft. But here the minimum length found in a female subject is 2 ft 4 inches, and the maximum length found in a male subject is 9 ft 6 inches. The greatest width has been usually found in the Coecum and the average greatest width in these cases has been 2½ inches.

### MESOCOECUM (Tables D and E)

Mesocoecum has been found in 11 out of these 84 cases, i.e. in 13 per cent. of males and females taken together. This confirms the result of my observation on the first series of 65 cases, in which it was found in 14 per cent.

### ASCENDING MESOCOLON (Tables D and E)

Ascending mesocolon has been found in 15 out of these 84 subjects, i.e. in 17·8 per cent. of both males and females taken together. This confirms the result of my observation on the first series of 65 cases, in which Ascending Mesocolon was found in 17 per cent.

### DESCENDING MESOCOLON (Tables D and E)

Descending Mesocolon has been observed in 23 out of these 84 cases, i.e. in 27 per cent. of both sexes taken together. In my first series of 65 cases, Descending Mesocolon was found in 21·5 per cent. It will be observed that a Descending Mesocolon has been found in a large percentage (43 per cent.) of the female cases of the present series (Table D).

Taking the average of 149 cases (first and second series), a Descending Mesocolon is found in 24·5 per cent.

The following table shows the results of the observations on the two series of cases separately, and the average of the two series considered together.

Table F.

| | Stomach | | | Length of Duodenum | Length of Jejunum and Ileum | No. of Peyer's Patches | Length of Vermiform Process | Meso-colon | Mesocolon | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Capacity | Length | Breadth | | | | | | Ascending | Descending |
| (*a*) Average of first series of 65 cases ... | 71·5 oz. | 11·25″ | 5·8″ | 9·5″ | 21′ | 23 | 2·5″ | 14 | 17 | 21·5 |
| (*b*) Average of second series of 84 cases... | 75 oz. | 11·1″ | 6″ | 9·4″ | 20′ 6″ | 20·8 | 2·94″ | 13 | 17·8 | 27·3 |
| (*c*) Average of both series taken together | 73·5 oz. | 11·2″ | 5·9″ | 9·4″ | 20′ 9″ | 21·6 | 2·8″ | 13·4 | 17·4 | 24·5 |

### CONCLUSION

The average total length of the intestinal canal in Hindus is thus calculated to be 26 ft, and is thus much less than the length noted in persons who take a greater proportion of meat and a smaller proportion of carbohydrate food.

In persons living on bulky carbohydrate food the intestinal canal is expected to be longer in order to accommodate a bulky refuse. Thus in herbivorous animals the intestinal canal is comparatively longer, whereas in carnivorous animals the intestinal canal is shorter but more muscular.

The experiments of Babak (cited from Madinavetia, *Physiologia Palleologica de la Digestion*, Madrid, 1910) have shown that in animals of the same species even, taken quite young and growing, if some are fed exclusively upon vegetable food and others mostly on meat a similar adaptation in length occurs, viz. a greater length in the animals fed on vegetable diet.

In Japanese and Chinese, who also live mostly on a bulky carbohydrate food, a marked increase in the length of the intestinal canal has been noted. But here taking the average of 149 cases, there is rather a decrease in the length of the intestinal canal observed. Thus it occurred to me that greater accommodation for the excreta may be provided by an increase in the breadth rather than an increase in length. So I noted the breadth as well in the second series of 84 subjects. The average greatest breadth of the small intestine in these cases has been found to be $1\frac{1}{2}$ inches and that of the large intestine

2½ inches. So it is probable that the intestinal contents are comparatively rapidly ejected as they excite peristalsis mechanically by their bulk and nature and as such these vegetarians as a rule seldom suffer from constipation and the intestines rarely remain loaded.

In carnivorous animals a shorter vermiform process is found than in herbivorous animals. Consistently with this a larger vermiform process is expected to be present in vegetarians. But here it is shorter and it may be that the nature of the diet plays no part in determining the length of the vermiform process.

I thank my assistants, specially Dr Nagendra Nath Chatterjee, Assistant Professor of Anatomy, for their kind co-operation in carrying out these observations.

# REVIEW

## Cunningham's *Manual of Practical Anatomy*, Vols. I, II and III.

Seventh edition. Henry Frowde and Hodder and Stoughton.

As an example of the high standard of excellence to which the art of book-production can attain, this new edition of Cunningham's *Practical Anatomy* is superb. The original two-volumed manual is now published in three volumes, owing, we are told, to the introduction of many new illustrations of dissections, sections, and radiographs, and to the amplification of the instructions for dissection. The Basle nomenclature is retained throughout, while at the commencement of the first volume is a glossary of the two terminologies.

The descriptive part of the work is very complete, and the instructions to the dissector are clear and practical. We realise the advantages of the metric system in weights and measurements, but surely the literal translation of $1\frac{1}{2}$ inches into 38 mm. gives the student an impression of unjustifiable accuracy.

The movements of joints are described in some detail, but we observe a departure from the usually recognised classification of joints by terming the sacro-iliac joint a diarthrosis, and the intercentral and intersternal as synchondrodial rather than symphysial joints. The radiographs of bones, joints, and injected arteries are well produced. The illustrations, both coloured and uncoloured, are extremely fine; indeed, it is doubtful whether they are not too fine. Experience shows that students who rely on illustrations for visual memorization, learn their anatomy in two dimensions, and possess but a feeble appreciation of depth.

And this raises the question as to whether a practical dissecting manual, by undue elaboration, does not tend to defeat its own ends. The aim of a dissecting manual is, we take it, to show the student how to set about displaying the various structures of the body, and, when displayed, how to identify them. It should draw his attention to points of use and interest which he might otherwise overlook, but it should direct his observation and not observe for him. It should aim at giving the student a correct sense of proportion, laying adequate stress on features of importance, and avoiding undue emphasis on unimportant structures. In connection with this point, we note that the description of the gleno-humeral ligaments implies that they are equally important as the coraco-humeral and other ligaments of the shoulder-joint. Lastly, a practical anatomy book should have due regard for the relatively limited time set apart for anatomy in the modern curriculum, a curriculum which is becoming more and more crowded with courses of instruction in the side-branches of medical science. We are far from agreeing with those who advocate the elimination from anatomical teaching of all details which have not a direct and obvious application to medical and surgical matters, but we think it must be admitted that there is a limit to the assimilative powers of the medical student, and we believe that this limit is overstepped by the elaborate detail and the unnecessary complexity of these volumes of practical anatomy. We remark, by way of illustration, that no less than four superficial patellar bursae are described, a subcutaneous, a subfascial and a subtendinous prepatellar bursa, and a subcutaneous infrapatellar bursa. Again, the diagram of the brachial plexus as given on page 40 of vol. I is one which no average medical student has the time to master during his dissections. In short, it seems to us that these books err in containing too much descriptive detail which overtaxes the student's powers, and too plentiful and too excellent illustrations which tend to replace the student's own powers of observation altogether. We are reminded of a certain elaborate type of guide-book which requires so much study and concentration that the sightseer has not the time to contemplate sufficiently the features which the book purports to point out.

# INDEX


Aborigine, Australian, tibia of, W. Quarry Wood, M.D., F.R.C.S. (Edin.), 232
Acanthias blainvillii, constrictor muscles of the branchial arches in, Edward Phelps Allis, Jr, 222
Alexander, G. F., M.B., Ch.B. (Edin.), the ora serrata retinae, 179
Allis, Edward Phelps, Jr, the constrictor muscles of the branchial arches in Acanthias blainvillii, 222
Amphibia, development of the hypobranchial and laryngeal muscles in, F. H. Edgeworth, M.D., 125
Anomalies, cardiac and genito-urinary, in the same subject, Alexander Blackhall-Morison, M.D., F.R.C.P., and Ernest Henry Shaw, M.R.C.P., 163
Arteries, umbilical, persistence of, as blindly-ending trunks of uniform diameter in the Indian domestic goat, W. N. F. Woodland, D.Sc., I.E.S., 309
Asiatic brains, fissural pattern in four, Sydney J. Cole, M.A., M.D. (Oxon.), 311
Australian aborigine, tibia of, W. Quarry Wood, M.D., F.R.C.S. (Edin.), 232

Barclay, A. E., M.A., M.D. (Camb.), models of the human stomach showing its form under various conditions, 258
Barclay-Smith, E. In Memoriam, Professor Alexander Macalister, M.D., F.R.S., etc., 1844–1919, *Portrait*, 96
Blackhall-Morison, Alexander, M.D., F.R.C.P., persistent foramen primum, with remarks on the nature and clinical physiology of the condition, 90
Blackhall-Morison, Alexander, M.D., F.R.C.P., and Ernest Henry Shaw, M.R.C.P., cardiac and genito-urinary anomalies in the same subject, 163
Body, surface of, motor points in relation to, R. W. Reid, M.D., F.R.C.S., 271
Brain, Asiatic, fissural pattern in, Sydney J. Cole, M.A., M.D. (Oxon.), 311
Branchial arches in Acanthias blainvillii, constrictor muscles of, Edward Phelps Allis, Jr, 222
Brash, J. C., and M. J. Stewart, a case of partial transposition of the mesogastric viscera, 276

Caecum, mammalian, the ileo-caecal region of *Callicebus personatus*, with some observations on the morphology of, T. B. Johnston, M.B., Ch.B., 66
*Callicebus personatus*, ileo-caecal region of, with some observations on the morphology of the mammalian caecum, T. B. Johnston, M.B., Ch.B., 66
Cardiac and genito-urinary anomalies in the same subject, Alexander Blackhall-Morison, M.D., F.R.C.P., and Ernest Henry Shaw, M.R.C.P., 163
Carter, J. Thornton, the microscopical structure of the enamel of two sparassodonts, cladosictis and pharsophorus, as evidence of their marsupial character: together with a note on the value of the pattern of the enamel as a test of affinity, 189
Cat, pronephros and early development of the mesonephros in, Elizabeth A. Fraser, D.Sc., 287
Cladosictis, sparassodonts, and pharsophorus, microscopical structure of the enamel of, as evidence of their marsupial character: together with a note on the value of the pattern of the enamel as a test of affinity, J. Thornton Carter, 189
Cole, Sydney J., M.A., M.D. (Oxon.), fissural pattern in four Asiatic brains, 311
Crew, F. A. E., M.B., sexual dimorphism in *Rana temporaria*, as exhibited in *rigor mortis*, 217
(*C. Rhinocephalus*), a cyclops lamb, Reginald J. Gladstone, M.D., F.R.C.S., and C. P. G. Wakeley, M.R.C.S., L.R.C.P., 196
Cunningham, D. J., Manual of Practical Anatomy, vols. I, II and III, seventh edition, Review, 332
Cyclops lamb (*C. Rhinocephalus*), Reginald J. Gladstone, M.D., F.R.C.S., and C. P. G. Wakeley, M.R.C.S., L.R.C.P., 196
Cyriax, Edgar F., M.D. (Edin.), on certain absolute and relative measurements of human vertebrae, 305

Dimorphism, sexual, in *Rana temporaria*, as exhibited in *rigor mortis*, F. A. E. Crew, M.B., 217

Edgeworth, F. H., M.D., on the development of the hypobranchial and laryngeal muscles in amphibia, 125
— on the development of the laryngeal muscles in sauropsida, 79
Embryo, functions of the liver in, J. Ernest Frazer, F.R.C.S. (Eng.), 116
Enamel, microscopical structure of, of two sparassodonts, cladosictis and pharsophorus, as evidence of their marsupial character: together with a note on the value of the pattern of the enamel as a test of affinity, J. Thornton Carter, 189
Epithelium, ciliated, in the oesophagus of a seventh month human foetus, F. H. Healey, B.Sc., 180
Exostoses, multiple, the nature of the structural alterations in the disorder known as, Arthur Keith, 101

Eye, posterior pole of, relative positions of the optic disc and macula lutea to, James Fison, M.A., M.D. (Cantab.), 184

Fison, James, M.A., M.D. (Cantab.), the relative positions of the optic disc and macula lutea to the posterior pole of the eye, 184
Foetus, seventh month human, note on the occurrence of ciliated epithelium in the oesophagus of, F. H. Healey, B.Sc., 180
Foramen primum, persistent, with remarks on the nature and clinical physiology of the condition, Alexander Blackhall-Morison, M.D., F.R.C.P., 90
Fraser, Elizabeth A., D.Sc., the pronephros and early development of the mesonephros in the cat, 287
Frazer, J. Ernest, F.R.C.S. (Eng.), functions of the liver in the embryo, 116

Gastro-intestinal tract of the Hindus, further observations on, Dr N. Pan, 324
Genito-urinary and cardiac anomalies in the same subject, Alexander Blackhall-Morison, M.D., F.R.C.P., and Ernest Henry Shaw, M.R.C.P., 163
Gladstone, Reginald J., M.D., F.R.C.S., and C. P. G. Wakeley, M.R.C.S., L.R.C.P., a cyclops lamb (*C. Rhinocephalus*), 196
Goat, Indian domestic, persistence of the umbilical arteries as blindly-ending trunks of uniform diameter in, W. N. F. Woodland, D.Sc., I.E.S., 309
Goddard, T. Russell, hypertrophy of the interstitial tissue of the testicle in man, 173
Graafian Follicle, ripe human, together with some suggestions as to its mode of rupture, Arthur Thomson, 1
Growth-disorders of the human body, studies on the anatomical changes which accompany certain. I. The nature of the structural alterations in the disorder known as multiple exostoses, Arthur Keith, 101

Healey, F. H., B.Sc., note on the occurrence of ciliated epithelium in the oesophagus of a seventh month human foetus, 180
Hindus, gastro-intestinal tract of, further observations on, Dr N. Pan, 324
Hypertrophy of the interstitial tissue of the testicle in man, T. Russell Goddard, 173
Hypobranchial and laryngeal muscles in amphibia, development of, F. H. Edgeworth, M.D., 125

Ileo-caecal region of *Callicebus personatus*, with some observations on the morphology of the mammalian caecum, T. B. Johnston, M.B., Ch.B., 66
In Memoriam, Prof. Alexander Macalister, M.D., F.R.S., etc., 1844–1919, *Portrait*, E. Barclay-Smith, 96
Interstitial tissue of the testicle in man, hypertrophy of, T. Russell Goddard, 173

Johnston, T. B., M.B., Ch.B., the anatomy of a Symelian monster, 208
— the ileo-caecal region of *Callicebus personatus*, with some observations on the morphology of the mammalian caecum, 66
Jones, Prof. Frederic Wood, D.Sc., voluntary muscular movements in cases of nerve lesions, 41

Keene, Mrs Lucas, and F. G. Parsons, sexual differences in the skull, 58
Keith, Arthur, studies on the anatomical changes which accompany certain growth-disorders of the human body. I. The nature of the structural alterations in the disorder known as multiple exostoses, 101

Lamb, cyclops (*C. Rhinocephalus*), Reginald J. Gladstone, M.D., F.R.C.S., and C. P. G. Wakeley, M.R.C.S., L.R.C.P., 196
Laryngeal and hypobranchial muscles in amphibia, development of, F. H. Edgeworth, M.D., 125
— muscles in sauropsida, development of, F. H. Edgeworth, M.D., 79
— nerves, recurrent, note on, Prof. F. G. Parsons, 172
Liver, functions of, in the embryo, J. Ernest Frazer, F.R.C.S. (Eng.), 116

Macalister, Prof. Alexander, M.D., F.R.S., etc., 1844–1919, In Memoriam, *Portrait*, E. Barclay-Smith, 96
Macula lutea and optic disc, relative positions of, to the posterior pole of the eye, James Fison, M.A., M.D. (Cantab.), 184
Meatus, external auditory, level of, Prof. F. G. Parsons, 171
Mesogastric viscera, case of partial transposition of, J. C. Brash and M. J. Stewart, 276
Mesonephros and pronephros in the cat, early development of, Elizabeth A. Fraser, D.Sc., 287
Models of the human stomach showing its form under various conditions, A. E. Barclay, M.A., M.D. (Camb.), 258
Motor points in relation to the surface of the body, R. W. Reid, M.D., F.R.C.S., 271
Muscle, abnormal, in popliteal space, Prof. F. G. Parsons, 170
Muscles, constrictor, of the branchial arches in Acanthias blainvillii, Edward Phelps Allis, Jr, 222
— laryngeal, in sauropsida, development of, F. H. Edgeworth, M.D., 79
Muscular movements, voluntary, in cases of nerve lesions, Prof. Frederic Wood Jones, D.Sc., 41

Nerve lesions, voluntary muscular movements in cases of, Prof. Frederic Wood Jones, D.Sc., 41
Nerves, recurrent laryngeal, note on, Prof. F. G. Parsons, 172

Oesophagus of a seventh month human foetus, occurrence of ciliated epithelium in, F. H. Healey, B.Sc., 180
Optic disc and macula lutea, relative positions of, to the posterior pole of the eye, James Fison, M.A., M.D. (Cantab.), 184

Ora serrata retinae, G. F. Alexander, M.B., Ch.B. (Edin.), 179

Pan, Dr N., further observations on the gastro-intestinal tract of the Hindus, 324
Parathyreoid duct of Pepere and its relation to the post-branchial body, Dr Madge Robertson, 166
Parsons, Prof. F. G., note on abnormal muscle in popliteal space, 170
— level of external auditory meatus, 171
— note on recurrent laryngeal nerves, 172
Parsons, F. G., and Mrs Lucas Keene, sexual differences in the skull, 58
Paterson, A. M., M.D., F.R.C.S., the anatomy of the peripheral nerves, 100
Pepere, parathyreoid duct of, and its relation to the post-branchial body, Dr Madge Robertson, 166
Pharsophorus, sparassodonts, and cladosictis, microscopical structure of the enamel of, as evidence of their marsupial character: together with a note on the value of the pattern of the enamel as a test of affinity, J. Thornton Carter, 189
Popliteal space, note on abnormal muscle in, Prof. F. G. Parsons, 170
Post-branchial body, parathyreoid duct of Pepere and its relation to, Dr Madge Robertson, 166
Pronephros and mesonephros in the cat, early development of, Elizabeth A. Fraser, D.Sc., 287

*Rana temporaria*, sexual dimorphism in, as exhibited in *rigor mortis*, F. A. E. Crew, M.B., 217
Reid, R. W., M.D., F.R.C.S., motor points in relation to the surface of the body, 271
Retinae, ora serrata, G. F. Alexander, M.B., Ch.B. (Edin.), 179
Review, The Peripheral Nerves, 100
— Cunningham's Manual of Practical Anatomy, seventh edition, vols. I, II and III, 332
*Rigor mortis*, sexual dimorphism in *Rana temporaria*, as exhibited in, F. A. E. Crew, M.B., 217
Robertson, Dr Madge, on the parathyreoid duct of Pepere and its relation to the post-branchial body, 166

Sauropsida, development of the laryngeal muscles in, F. H. Edgeworth, M.D., 79
Sexual differences in the skull, F. G. Parsons, and Mrs Lucas Keene, 58
Shaw, Ernest Henry, M.R.C.P., and Alexander Blackhall-Morison, M.D., F.R.C.P., cardiac and genito-urinary anomalies in the same subject, 163
Skull, sexual differences in, F. G. Parsons, and Mrs Lucas Keene, 58
Sparassodonts, cladosictis and pharsophorus, microscopical structure of the enamel of, as evidence of their marsupial character: together with a note on the value of the pattern of the enamel as a test of affinity, J. Thornton Carter, 189
Stewart, M. J., and J. C. Brash, a case of partial transposition of the mesogastric viscera, 276
Stomach, human, models of, showing its form under various conditions, A. E. Barclay, M.A., M.D. (Camb.), 258
Symelian monster, anatomy of, T. B. Johnston, M.B., Ch.B., 208

Testicle, hypertrophy of the interstitial tissue of, T. Russell Goddard, 173
Thomson, Arthur, the ripe human Graafian follicle, together with some suggestions as to its mode of rupture, 1
Tibia of the Australian aborigine, W. Quarry Wood, M.D., F.R.C.S. (Edin.), 232

Umbilical arteries, persistence of, as blindly-ending trunks of uniform diameter in the Indian domestic goat, W. N. F. Woodland, D.Sc., I.E.S., 309

Vertebrae, human, certain absolute and relative measurements of, Edgar F. Cyriax, M.D. (Edin.), 305
Viscera, mesogastric, case of partial transposition of, J. C. Brash, and M. J. Stewart, 276

Wakeley, C. P. G., M.R.C.S., L.R.C.P., and Reginald J. Gladstone, M.D., F.R.C.S., a cyclops lamb (*C. Rhinocephalus*), 196
Whittaker, C. R., F.R.C.S. (Edin.), nerves of the human body, 100
Wood, W. Quarry, M.D., F.R.C.S. (Edin.), the tibia of the Australian aborigine, 232
Woodland, W. N. F., D.Sc., I.E.S., note on the persistence of the umbilical arteries as blindly-ending trunks of uniform diameter in the Indian domestic goat, 309

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